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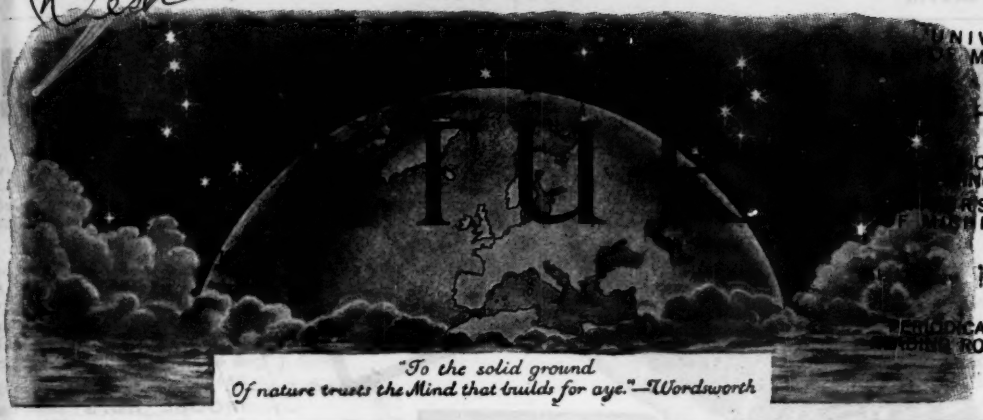

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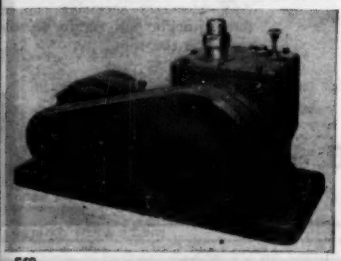

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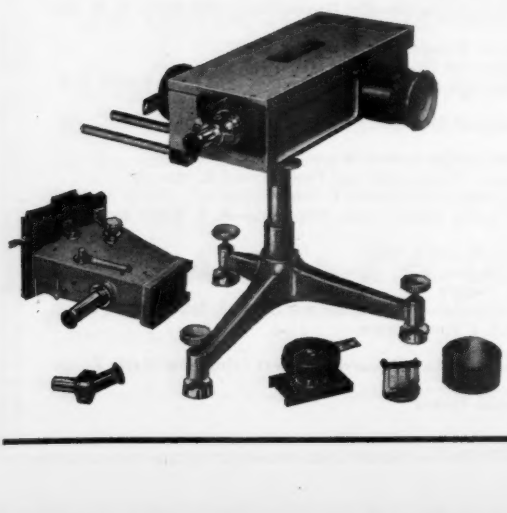

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SCIENTIFIC AND ENGINEERING MAN-POWER IN THE UNITED STATES

At a Sigma Xi meeting of the American Association for the Advancement of Science in December 1955, Dr. James R. Killian, jun., president of the Massachusetts Institute of Technology, outlined the strategy for augmenting the scientific and engineering man-power resources of the United States (*Amer. Sci.*, April 1956).

The nature of the present dearth of scientists and engineers, he said, is not simply a shortage of men. First and basically, it is a shortage of intellectual talent adequately educated and in the right place. Second, it is more a shortage of specific talents and skills adaptable to specific areas than a general shortage of numbers.

The shortage of high talent is aggravated by the fact that too many young people of exceptional intellectual ability drop out of the educational system before they have achieved an education which fully exploits their abilities. Of the ablest 50 per cent of high-school graduates, only about a third take degrees at college. Too many of the ablest youth of America fail to get the kind of education their abilities deserve. Without dropping standards, only a limited increase in college population can be achieved by stepping up the percentage of high-school graduates who go to college. These conclusions stress the importance of motivating and using more of the exceptional talent and directing attention to its conservation and cultivation.

The American nation would be better served, in Dr. Killian's opinion, by augmenting the total pool of exceptional talent so that all professions benefit, rather than by giving exclusive attention to science and engineering, even though the need for man-power in these fields is at the present time the most urgent. If an attempt is made to build up science and engineering through methods which apparently deprive other professions of talent, it may generate undesirable reactions and side-effects inimical to the welfare of science in the long run. It may also attract into science too many whose talents and predilections are more compatible with other kinds of careers and who would therefore become indifferent scientists and engineers.

Any grand strategy for augmenting scientific man-power must be related to a concerted effort to identify, encourage and more fully educate the top talent among youth.

Considerations of quality show that employers are not looking merely for university degrees; they are looking with a critical eye for very special qualifications—for a sound education in fundamentals, for analytical power, for a grasp of the new and advanced fields of technology. They are looking less for specialized competence at the first-degree level and more for men who have the versatility to follow successfully any one of several specialties.

These special demands indicate a great shortage of young engineers with a mastery of engineering science and thus a competence to handle new, advancing technologies, such as data processing, internal and external aerodynamics, energy conversion, communications, servo-mechanisms, 'molecular engineering' and solid-state physics for the design of materials, and similar functional components of technology.

Thus industry and government are pressing the colleges for engineers of more advanced education and analytical powers. They are looking for men with a fundamental, integrated education in science, engineering and the humanities, rather than for men specialized in some field of technology at the expense of fundamentals.

In the basic sciences the most pressing needs are for those scientists who have the imagination and trained creative power to make the discoveries and generate the new concepts which advance science.

Despite the critical shortage in the rank and file of good competent scientists and engineers, the really acute shortage is now in the 'flag-officer' group.

In the secondary schools the first requirement is to fill in the depleted ranks of science teachers and to do this, not with culls from other fields, but with teachers possessing a grasp of science and the perception to identify and stimulate young people with the bent and capacity for science.

There is the need for earlier identification of scientific talent and for more rigour, more emphasis on excellence in the secondary school. Much of the flight from science at the secondary school-level has resulted from the fear of science as a difficult subject of study.

Blame for this aversion to rigorous thinking rests with parents even more than it does with the schools. "The United States has hitherto displayed an attitude of condescension toward hard intellectual labour in our schools." The survival of the United States requires that the American people attach a higher value to the hard labour of rigorous thought.

The high-school programme should also be flexible, so that an early election of programme does not commit a boy or girl irrevocably to some prematurely selected career or educational programme.

Although the education of the future scientists and engineers has been neglected with effects endangering the nation, the education of other kinds of people is also important. No group of young people should be neglected in order to strengthen another. Secondary schools play a major part in maintaining the fluid, classless society of the United States. Methods for strengthening science teaching and increasing the numbers of scientists will not result in unfortunate distortion of this broader function of the secondary school programme. The highest priorities should be

given to better provision for intellectually gifted young people, greater stress on the more rigorous teaching of intellectual skills, and on higher standards of excellence for both teachers and pupils.

At the college-level there are many opportunities available for strengthening scientific and engineering education. The liberal arts colleges are the principal sources of candidates for graduate schools of science. The Wesleyan study and others have shown how remarkable has been the success of a number of small liberal arts colleges in preparing men and women to become distinguished specialists in science.

The needs of the colleges for science teachers is as serious as in the schools, and particularly in those institutions where little research is done; industry and other agencies have drawn the promising young material away by providing opportunities to do research and development and by higher compensation. More grants and fellowships should be given to enable professors of science in liberal arts colleges to have time off from teaching to do research or to have first-hand contacts with creative work in science in the universities or in industrial or government laboratories.

The professional schools of science and engineering have suffered in the competition for top-flight men. The engineering schools are especially vulnerable because their young and imaginative graduates and teachers—especially those in the advancing, growing fields of technology—are more in demand for non-educational employment than any other group in the educational institutions in the United States.

If engineering education is to meet this challenge it must find a way to make engineering schools a more attractive environment for top-flight engineers and thus for top-flight teaching of future engineers.

The teaching loads in engineering schools are very high, with the result that their staffs have too little opportunity for the creative work that leads to further professional development both as teachers and engineers.

The engineering profession or society can no longer be adequately served by a professional engineering education that is predominantly undergraduate. While qualified recipients of the bachelor's degree in engineering frequently go on for graduate study in other fields such as the physical sciences and management, the amount of advanced study in engineering still seems small compared with the advanced study required by the professions of law and medicine. The number of advanced degrees in the United States in engineering, both master's and doctor's, in 1953–54 totalled about 4,800, while the totals of M.D.'s and LL.B.'s were 6,757 and 9,898, respectively.

Many educators are also advocating changes in undergraduate engineering courses, and engineering education seems to show signs of the bold experimentation and innovation that marked it in its early days when it was struggling to throw off the unsympathetic sanctions of classical education. There is a spreading conviction that the engineering curriculum must include a larger content of basic science, less of its traditional compartmentalization, more emphasis on such fundamental functional aspects of engineering as materials, thermodynamics, fluid flow and energy conversion. It bodes well for the future quality of technology that some of the new ideas are originating in the engineering schools. A superb opportunity exists to provide a new type of liberal education polarized about science, unified by professional requirements, and relevant to the needs of our technological society. In the American institutes and schools of technology there is a vision of a new kind of university, a modern university built around science and social technology rather than classical studies, but embracing the arts, the social sciences and the humanities as essential and equal partners in its corporate aims and culture.

The goal should not be set as an academic numbers race with the Russians. The Russian educational system serves the State, the American the individual. The Russians are highly specialized in their scientific and engineering education and the United States is developing towards more fundamental generalized education, especially at the undergraduate-level.

One of the great difficulties is the surprising amount of fear of science and of a misreading of what science really is. Some of this adverse reaction arises from anti-intellectualism, from the disdain and distrust toward the learned man and the realm of reason. This drawing away from science is related to an attitude of antagonism and fear with respect to scientists. There is the common attitude that because a man is a scientist, he is disqualified for public and private administrative responsibility even though he may have all the qualifications.

This attitude reflects something wrong in the relationship of the scientist to society and in society's current estimate of the scientist. The scientist and engineer are themselves partly to blame for the manner in which their function in public affairs has been derogated. They have tended too much to professional parochialism.

The humanist, too, has a responsibility for this hurtful condition. There is still too much of the separatist spirit among the lower reaches of the humanists, too much facile criticism of science as materialistic, too much envy of the scientist for his intellectual achievements, too much protesting that only in the liberal arts can the true gospel of man be found.

It is the great humanistic responsibility of colleges and universities to stress the kinship, indeed the unity, of all knowledge, and to ease the vested interests and snobberies which sometimes appear among learned men. Objectivity, for example, is not the exclusive monopoly of science, nor humanism the tight monopoly of the liberal arts.

If science is to continue to prosper it must combat the notions that science and engineering are incompatible with the disciplines of the great humanities, and that they are narrowly materialistic and destructive of human values. Scientists have an obligation to make this true character of science better understood by the balanced and tolerant presentation of science as one of the powerful means by which man

can increase his knowledge and understanding, and still remain humble and ennobled before the wonder and the majesty of what he does not understand.

As Dr. Caryl Haskins, president of the Carnegie Institution of Washington, recently remarked, it seems that the United States and Great Britain have problems in common with regard to the training of scientists and engineers and to the supply of the man-power of the right calibre. Dr. Killian's opinions as expressed in his address at the American Association proves this. All men of science and those concerned with scientific man-power problems would do well to read this address with the object of producing not only more, but also better educated, scientists and engineers in the future.

PRINCIPLES OF THE DYNAMO

Electromagnetic Principles of the Dynamo

By Prof. E. B. Moullin. (Oxford Engineering Science Series.) Pp. xi+367. (Oxford: Clarendon Press; London: Oxford University Press, 1955.) 50*s*. net.

IT happens not altogether infrequently that a book which has been projected and upon which a substantial amount of work may have been done fails for one reason or another to achieve completion and publication. Most of those who, twenty-three years ago, read in the preface to Prof. E. B. Moullin's book, "Principles of Electromagnetism", that he hoped to publish shortly a book entitled the "Principles of the Direct Current Dynamo", must long ago have assumed that the volume would never now appear. On the contrary, this book, under the slightly altered title of the "Electromagnetic Principles of the Dynamo", has now taken its place in the literature of electrical machines.

Prof. Moullin explains in the preface that the manuscript, almost complete, lay aside from 1933 until 1950 and was then on the point of being discarded. At that time, Mr. G. E. Middleton, who had for many years been engaged on the design of electrical machines, joined the staff of the University of Cambridge, and he was invited to read the manuscript and express an opinion as to whether it would still be worth while to complete the book. Happily, Mr. Middleton recommended the completion of the task, and the author records his appreciation of the invaluable help rendered by him in the completion and revision of the manuscript.

The book conforms closely to the terms of its title and deals almost exclusively with the electromagnetic principles of direct-current machines. After an initial chapter on basic principles come five chapters dealing individually with the estimation of the ampere turns on the poles, the magnetic effects of the armature current, characteristic curves, efficiency and energy losses and commutation. These are followed by two chapters, one of which deals with a group of special machines, and the other, the last chapter, is entitled "Supplementary Matter". This treats in considerable detail certain topics which have been dealt with less fully earlier in the book and with a number of problems which link alternating-current with direct-current machines.

Perhaps the essential quality of this book can best be described by saying that, in it, the author has asked himself and has answered to his own satisfaction most of the searching and often awkward questions which an acute and critical mind would ask when presented with the conventional treatments of the theory of electromagnetic machines. Many of the paradoxes and conundrums which tantalized electrical engineers of an earlier generation receive serious study and elucidation. The induction of the electromotive force in the homopolar machine, the magnetic force on conductors embedded in slots and the e.m.f. in such conductors are examples of these problems. The treatments which are given of such topics as commutation and of the load characteristics of machines are exceptionally thorough and penetrating. There is a particularly interesting analysis of the Rosenberg dynamo, a machine which has nowadays a greatly increased interest as it is, in principle, the prototype of an important class of control machine.

At the end of the book is a collection of examples, eighty in number, taken for the most part from Cambridge examination papers, which illustrate the topics discussed in the text, each example being accompanied by an outline of its solution.

Mathematical analysis is used in varying degree in relation to nearly all the subjects with which the book deals, but no advanced methods are involved. The standard required is well within the competence of a second- or third-year university student. The real interest lies, however, in the critical questioning of the assumptions underlying many accepted pieces of theory and in their justification often by more than one method. This searching examination of the physics of machine problems, with the consequent quantitative assessment of the validity of assumptions, not only illuminates the problems themselves but also illustrates that spirit of inquiry which is an essential characteristic of the scientific mind.

This is a stimulating book which will interest and satisfy the teacher concerned with the subject of electromagnetic machines, and it will do the like for the student whose intellectual curiosity and insight have crossed the 'pons asinorum' of his subject. While it is clearly for the student that this book has been written, it is not too much to say that the experienced designer of electrical machines may find in its pages a new approach to some fundamental matter which may elucidate an intractable practical problem.

J. GREIG

OPTICS OF CHARGED PARTICLES

Handbuch der Physik

Herausgegeben von S. Flügge. Band 33: Korpuskularoptik. Pp. vi+702. (Berlin: Springer-Verlag, 1956.) 122.50 D. marks.

THE first volumes of the new "Handbuch der Physik" are out and give every promise of its being a worthy successor to the original edition of Geiger and Scheel, which appeared between 1926 and 1930. The intervening quarter of a century has seen some notable advances in international co-operation as well as great progress in physics itself, and both developments are reflected in the new edition. The contributors are drawn from many countries, and the articles may be in English, French or German. The progress of physics is reflected in the complete recasting of the treatment and its extension to fifty-four volumes. The change is exemplified in the subject-matter of Vol. 33, "Korpuskularoptik", one of the first of the new series to appear. Vol. 22 of

the old series, the second edition of 1933, included mention of beta-ray and mass spectrometers and of electron diffraction; but there was little on sources of electrons and ions, and nothing on their optics. We now have a volume of more than seven hundred pages dealing with these subjects and with the electron microscope. The concern with instrumentation is new to the "Handbuch". The emphasis previously was very much on the fundamentals of physics; although technical physics in the wider sense was given some space, it has now been excluded in order to keep the number of volumes within reasonable limits.

The individual articles in Vol. 33 vary considerably in length and treatment. The first, on electron and ion sources, by D. Kamke, is perhaps too much a collection of types of ion guns (in eighty-five pages), and, even so, sources for accelerators are left to Vol. 44, where they will be treated in conjunction with injector systems. Electron guns are given only thirty-three pages, and a number of important aspects are comparatively neglected or omitted, such as the work of Haine and Einstein on medium-high-voltage guns and the more recent work of Klemperer on waist formation in electron beams. In general, very few pieces of work later than 1953 are cited. The section on electron and ion optics by W. Glaser, on the other hand, gives a balanced and thorough treatment of its subject. It is essentially an abbreviated version, in 270 pp. instead of 700 pp., of his monumental "Grundlagen der Elektronenoptik". Every topic of any importance is handled with rigour and economy, including deflecting fields and systems with curved axes. A supplementary bibliography includes references well into 1955.

Similarly, S. Leisegang's treatment of the electron microscope is a *zusammenfassende Bericht* in the best German manner. It runs to 150 pages with 137 figures and is almost a "Handbuch" in itself. In addition to the design and performance of the instrument, fundamental problems of image formation are dealt with, such as phase effects and energy losses in the specimen. The bibliography is up to date.

The final two articles, on mass spectrometers by H. Ewald and on beta-ray spectrometers by T. R. Gerholm, have much in common in mode of presentation. Each describes, in sixty-odd pages, the various types of instrument which have been devised for the respective methods of analysis: principles, practical details of construction, and efficiency of operation in terms of gathering aperture and resolving power. The treatment of beta-ray spectrometers is rather more critical, perhaps, in its comparison of different types. It ends with a conversion table, to six figures, from electron momentum (in gauss-cm.) to equivalent energy from just below 1 keV. up to nearly 30 MeV. The bibliography in each article runs into 1955. It is perhaps due to the geographical position of the author (Sweden) that, in addition to being the only one in this volume to write in English, he is also alone in making any appreciable reference to Russian work.

On the other hand, Gerholm's article is by no means the only one in which misprints occur with a greater frequency than is to be expected in a work of this kind, and in the German even more than in the English text. It is perhaps a reflexion of haste in publication, in an endeavour to keep to the announced intention of issuing the whole work within three years. Layout, printing and illustration are up to the standard of the earlier series, but the binding may not stand up so well to the hard use which the "Handbuch" must expect. One other point needs mention: the absence, not only from this volume but also from the list of contributors to others, of many of the leading exponents of the respective subjects. Looking back into Vol. 22 of Geiger and Scheel, one finds that most of the articles were by physicists who had been major contributors to their subject: Bothe, Frisch, Gerlach, Hahn, Meitner, Paneth, Ramsauer, Stern. Furthermore, it is not a question of 'hind-sight', as most were already of established international reputation and almost all held a chair at a German university. It is probably another sign of the growth of physics, in speed and complexity of research as well as in its technical importance, that its leading men are now too busy to write reviews of their subject. In the present volume only one author bears the title of professor, and he is now in an industrial laboratory in the United States.

V. E. Cosslett

RESEARCH ON BREWING

European Brewery Convention

Proceedings of the Congress, Baden-Baden, 1955. Pp. xi+358. (Amsterdam: Elsevier Publishing Company; London: Cleaver-Hume Press, Ltd., 1955.) 55*s*.

THE idea of science infiltrating into brewing still frequently produces a reaction from the layman on the grounds that, first, beer has been brewed for more than six thousand years, so there can be little still to learn; second, the less the scientist has to do with it the better because it used to be better than it is (in fact, it is even hinted that nowadays "beer is made from chemicals"); third (triumphantly), brewing is an art and not a science. The first two points are born of ignorance of the real position, and the truth of the third depends on the sense of the word 'art': in so far as it refers to experience and skill in 'know how' it may be correct. Convincing arguments could be presented to explain why research in brewing is necessary, but perhaps it is adequate here to say that more research is being done in this field than ever before.

In Britain there is the Brewing Industry Research Foundation, financed entirely by the brewing trade, and organizations of a similar, albeit less comprehensive and fundamental, character exist on the Continent of Europe and in North America. In Europe there was formed after the Second World War a Brewery Convention which embraces those countries with organizations competent to be members. Congresses are held biennially at different centres, and scientific and technical papers on brewing and malting are presented. The attendance has risen to several hundreds of brewers and brewing scientists, and so far the temptation has been resisted of splitting the meetings into two sections, one for the brewers and the other for the scientists. Should that happen, one of the chief objects of the founders will have failed.

The present volume contains the papers and discussions presented at the 1955 congress at Baden-Baden. A glance at the papers shows the high standard of most of the three dozen papers, including the reports of the Convention's two standing com-

mittees, on barley and analysis. The papers are grouped under headings covering raw materials: that is, barley and malt and hops; carbohydrates, proteins and yeasts (surely wide enough); and 'miscellaneous', covering topics from the influence of alcohols and esters on beer foam to the survival of pathogenic bacteria in beer.

Some of the papers on hops show the recent progress in hop resin chemistry, which has been quite significant. The eventual practical result will be the more economical use of hops by the brewer. Investigations on barley and malt range from dormancy to cytolytic activity during malting. An important activity of the barley committee is the arrangement of simultaneous trials in many countries on new varieties of brewing barley. A topic touched upon, and which may well attract more future attention, is that of the barley gums and polysaccharides other than starch of barley and malt.

Two other fields of perennial interest have papers devoted to them in this volume—yeasts and barley proteins. The mechanism of yeast flocculation in fermentation is still imperfectly understood, and the proteins in beer must always rank high in research because they are associated with the curse of haze and the blessing of 'head'.

The Convention has in preparation a six-language dictionary of brewing and malting terms.

H. J. Bunker

A DICTIONARY FOR THE NEW WORLD

Webster's New World Dictionary

Pp. xiv+1702. (London: Macmillan and Co., Ltd., 1956.) 70*s*. net.

THIS "New World Dictionary" contains more than 142,000 vocabulary entries. It is an up-to-date record of words and phrases, giving full etymologies and a discriminative choice of synonyms. The entire work comprises a single alphabetical listing of words and their meanings, abbreviations, and personal, place and Christian names, etc. This has the distinct advantage of rendering it almost impossible to miss an insertion if it is there at all.

Both British and American forms of spelling are given, either in their alphabetical sequence or with cross-references. For example, there are about forty main entries with the prefix "sulf-", and one entry "sulph-", followed by a cross-reference to the others.

The insertion of the names of distinguished men and women in a general dictionary of this sort is open to question. For example, Sir Alexander Fleming is described as "one of the discoverers of penicillin"; there is no indication who the others were, and Sir Howard Florey is not included. Lord Rutherford is described as a "British physicist, born in New Zealand; received the Nobel prize in chemistry, 1908"—not a very informative description of the great atomic physicist for a general reader. James Watt is described as a "Scottish inventor", but what he invented or discovered is not given. Yet, in other cases the compilers show considerable ingenuity in their brief descriptions; for example, Charles Darwin is described as the "English naturalist, originated theory of evolution by natural selection".

It is difficult to conceive of the qualifications needed by any living or dead person to justify his inclusion in such a compilation as this. Browsing at random, one comes across the names of Bohr, the two Braggs (William and Lawrence), Conant, Julian Huxley and Urey. Appleton appears not under his own name, but under "Appleton layer". Conversely, thinking at random, one looks for Bronk, Chadwick, Dale, Hale, Meitner and Spencer Jones; but these are not there. Again, among the abbreviations, UNESCO is explained, but not WHO. There are only three insertions under the abbreviated form of "Fellows" of learned societies, namely, F.R.S. (Fellow of the Royal Society—though the Society itself is not inserted), F.R.S.L. (Fellow of the Royal Society of Literature) and F.R.S.S. (Fellow of the Royal Statistical Society). In order to avoid the sins of omission and commission in a compendium such as this, it might have been wiser to omit proper names, abbreviations and very technical terms and to stick to general words and their meanings; for the resulting tendency is to become a not very comprehensive encyclopædia which might give only enough information to enable the reader to satisfy the question-master in a parlour or quiz game.

Again, where certain common names have connotations different in the New World from the Old, then the definitions should be more explicit. For example, "cowslip" is described as "1, the marsh marigold, a swamp plant with yellow flowers. 2, a wild plant of the primrose family with yellow flowers; English primrose". This description would have been more informative and less misleading if it had ended at the semicolon, and if '(Amer.)' had been inserted at the end of 1, and '(Brit.)' at the end of 2. "Bluebell" is described as "any of the various plants with blue-bell-shaped flowers, as the wild hyacinth, harebell, etc.". This vague approach will cause many local arguments. The "snowdrop", besides receiving the correct British identity, is also defined as the "common anemone"; whereas "hazel" is described as a group of trees or shrubs of the birch family. British botanists will lift their eyebrows at these loose and, in some cases, erroneous definitions. The term "Alsatian" from the canine point of view is described only as "a variety of police dog"; but this breed did not originate from Alsace, though the reason for the name is well known. Cross-reference to "German shepherd dog" should have been given. Among the examples of "black-birds" is "the common English thrush"; the "robin" is described as "1, a large North American thrush with a dull-red breast and belly. 2, a small European thrush with a yellowish-red breast". Generally speaking, this may be accepted by the ornithologist; but it is just terse enough to confuse a layman.

The examples given indicate the difficulties of compiling a dictionary which will satisfy both the British and the American English-speaking peoples. Perhaps the compilers have aimed at too many insertions at the expense of clarity and sometimes even accuracy. Indeed, it seems that the time has come when we must admit that British and Americans, though speaking the same language basically, have rather different vocabularies. This New World Dictionary will certainly satisfy the general inhabitants of the New World, for it is biased in that direction. Nevertheless, many of the technical terms which are common to both worlds are quite cleverly defined and are certainly up to date; so it might well be worth considering an Old World version of this New World Dictionary.

Handbuch der Physik

Herausgegeben von S. Flügge. Band 2: Mathematische Methoden, 2. Pp. vii+520. (Berlin: Springer-Verlag, 1955.) 88 D. marks.

THIS is a valuable compendium of methods of mathematical physics which, while in no way threatening the pre-eminence of "Courant–Hilbert" and "Jeffreys and Jeffreys", makes its own selection of material and thus contains some valuable techniques which are absent from those standard works. It is stronger, particularly, on algebraical and geometrical methods. A fairly substantial account of the theory of groups (including group representation), rings, fields, ideals and linear algebras, with indications of fields of their application, is given first. It is followed by an account of analytical geometry, differential geometry and field theory, Riemann geometry, tensors, spinors, and canonical transformations. Next follows the longest section—functional analysis, by Prof. I. N. Sneddon; this section is in English, whereas the rest of the book is in German. He begins with a synopsis of Banach space theory and then goes on to a rather full account of integral transforms, including the Laplace, Fourier, Mellin and Hankel transforms, and various finite transforms such as the Legendre transform and other transforms arising from equations of Sturm–Liouville type. This section concludes with an account of operators in Hilbert space and Schwartz's theory of distributions.

The following, and second longest, section of the book is a fairly full account of numerical and graphical methods, which though on conventional lines contains many useful tips about practical procedure. Half this section is devoted to initial-value, boundary-value and eigen-value problems for ordinary and partial differential equations and to integral equations and functional equations. The book concludes with a rather brief account of modern computing machines of both the analogue and digital types. There are subject indexes, both in English and in German.

Like "Courant–Hilbert", the book will perform its most useful service by introducing to applied mathematicians a number of techniques which they are apt sometimes to regard (erroneously) as proper only to investigations in pure mathematics. A copy could usefully be purchased for any mathematics or physics library.

M. J. Lighthill

Thermodynamics and Statistical Mechanics

By Arnold Sommerfeld. (Lectures on Theoretical Physics, Vol. 5.) Translated by J. Kestin. Edited by F. Bopp and J. Meixner. Pp. xviii+401. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1956.) 7 dollars.

SOMMERFELD died before completing this present volume of his theories on theoretical physics, but he had done a good deal of the work and the plan of the rest was clear enough for Profs. Bopp and Meixner to complete it, following as closely as possible the author's intention.

The book, which is now available in translation, shows no sign of these difficulties, and the treatment has preserved throughout Sommerfeld's characteristic clarity of approach and his emphasis on physical principles. He follows Boltzmann rather than Gibbs, even to the point of having to resort to the Darwin–Fowler contour integration method in the derivation of Fermi–Dirac and Bose–Einstein statistics in order to cope with the combinatorial difficulties. To the reviewer, who was introduced in Sommerfeld's lectures to the beauty and simplicity of the method of the grand canonical ensemble, this is a source for regret. It is clear from the author's preface as well as from the note by the editors that Sommerfeld himself was not satisfied with this section and might have intended to change it if he had had the opportunity to do so.

The treatment starts with thermodynamics as a logically independent subject and only later reaches statistical mechanics by way of the elementary kinetic theory of gases, an order which is not only the historical but also the simplest one logically if perhaps not deductively.

Chapter 4, which deals with the general principles of statistical mechanics, is perhaps the least satisfactory for the reasons already stated.

Chapter 5 gives an outline of an exact kinetic theory of gases and covers, in particular, transport phenomena and deviations from statistical equilibrium. This chapter, which is almost entirely due to the editors following what seemed to be Sommerfeld's intentions, is a useful addition in bringing out a very practical approach to many problems not usually covered in such books.

The book is a welcome addition to the text-books on this subject. Like the others in the series, it displays Sommerfeld's attitude of putting practical problems and their solution above abstract principles, an attitude by its nature closer to Boltzmann than to that of Gibbs.

R. E. Peierls

The Chemical Constitution of Natural Fats

By Prof. T. P. Hilditch. Third edition, revised and enlarged. Pp. xix+664. (London: Chapman and Hall, Ltd., 1956.) 95*s*. net.

SINCE the second edition of this book in 1947, there has been a broadening of interest in the natural fats, which, through their number and variety, provide almost endless opportunity for systematic study. This has occurred, first, because shortages due to war and later economic factors have stimulated research for alternative fats for food and other purposes; at the same time, the development of new and more delicate methods has brought rewarding results in a field in which their introduction had become essential if further important advances in knowledge were to be made. Prof. T. P. Hilditch has thus been faced with an arduous task in incorporating the mass of new material available in the third edition of this book, and he has overcome the difficulties with much success.

The new edition naturally contains extensive additional data on the fatty-acid composition of many fats. More important, however, are the three rewritten chapters which discuss recent material advance in knowledge concerning the component glycerides, the nature of which plays a part in determining the industrial uses to which fats are put. Two other largely rewritten chapters also call for comment. The first is that which is concerned with the chemical constitution and synthesis of fatty acids, particularly of the naturally occurring unsaturated acids, and of some acids which occur rarely and in small amount. Many uncertainties are now cleared up, and some of the findings may prove of considerable importance in the biochemical understanding of fats. The second is important because in it are presented the methods of research on fats, with particular emphasis on such newer approaches as

low-temperature crystallization from solvents and spectrophotometry, which are yielding valuable results.

This book, which includes findings published as recently as the end of 1954, thus remains a comprehensive reference book of great value in the field of natural fats and reflects throughout the experienced judgment of its author, who has carried out so much pioneering work on this subject for so many years.

Comprehensive Inorganic Chemistry

Vol. 4. Edited by Prof. M. Cannon Sneed and Prof. Robert C. Brasted. Zinc, Cadmium, and Mercury; by Howard M. Cyr and the Editors. Scandium, Yttrium, and the Lanthanide Series; by Thomas D. O'Brien and the Editors. Pp. xii+193. (Princeton, N.J.: D. Van Nostrand Company, Inc.; London: Macmillan and Co., Ltd., 1955.) 37*s.* 6*d.* net.

IN judging a book like this, one naturally takes a few test samples, preferably on familiar topics; so I started by looking up the separation of the rare earths. I found that solvent extraction was dismissed as being no better than fractional crystallization; the authors have evidently overlooked the not inconsiderable literature on the use of tributyl phosphate. Ion exchange was somewhat better assessed; but the account was marred by a quite inadequate description of ion exchangers in general, going right back to peat, greensand and clay, which no sensible person would attempt to use for the separation of the rare earths. Moreover, the facts about the ion exchange methods actually used for the rare earths seemed scrappily chosen. A minor point was the use, without explanation, of the name "Manhattan Project". Does everyone nowadays know the name?

Next I tried looking up the calomel electrode, on which I found two sentences, giving its potential and its reproducibility, but no word at all of what it is or how it works. There were indeed similar inadequacies at every sampling point, although some attempt seems to have been made to repair the deficiencies of earlier volumes by means of a liberal sprinkling of thermodynamic and crystallographic data.

The root of the trouble probably lies in the basic conception of the series, with its uneasy combination of encyclopædic treatment with efforts to inculcate basic principles. The two can be integrated, as Sidgwick has shown. But inorganic chemistry is now so vast and complex that we shall probably be better served in future by books falling definitely into one category or the other. H. A. C. McKAY

Physical Properties of Chemical Compounds

Compiled by R. R. Dreisbach. Edited by the Staff of *Industrial and Engineering Chemistry*. Pp. iv+536. (Washington, D.C.: American Chemical Society, 1955.) n.p.

THIS book tabulates, for 504 cyclic organic compounds, properties such as boiling point, density, viscosity, latent heat and a number of derived values (for example, constants for the Antoine equation). Some properties have been checked or derived by the use of well-known equations or of others devised by the compiler.

The compounds may be put into two classes; the first comprises hydrocarbons (328) and sulphur compounds (51). For these, the primary data are drawn from the work of the American Petroleum Institute Research Projects. It is known that properties have been determined by these for a large number of highly purified compounds; but, to the outsider, it would appear that, for some items recorded by Project 44, for example, tritriacontyl*cyclo*pentane, values have been derived by mathematical relationships such as were devised by Smittenberg for density and refractive index in some homologous series of hydrocarbons. If this is so, it is perhaps questionable how far one is justified in applying further equations to values so obtained.

The other class is a miscellaneous group: phenols (52), halogenated benzenes (27), amines, etc., for which the basic data have been taken from the general literature or have been specially determined in the Dow laboratories.

Among minor comments, the title of phenol 25 has been mistyped, the tertiary amyl group is consistently formulated as $-CH_2 \cdot C(CH_3)_3$, and the calculated surface tension of *n*-tetratriacontylbenzene is quite out of step with that of its several neighbours. There is, however, one serious blemish; phenols 37 and 51 are the same compound recorded under different names and, except for molecular weight and PV/RT, every figure differs, that of the boiling point by 11°. The seriousness lies in the fact that the data for forty-six other phenols have been taken from the same source as those for 37, so that, short of drawing invidious distinctions, at least a shadow of doubt falls on about a hundred items. B. A. ELLIS

Minerals in World Industry

By Prof. Walter H. Voskuil. Pp. vii+324. (London: McGraw-Hill Publishing Company, Ltd., 1955.) 43*s.*

THIS is an authoritative study of the part played by commercially important deposits of mineral substances in peace-time economy, and also in international politics. It has taken two World Wars to bring home to both politicians and the public the prime importance to great nations that lies in the possession or control of deposits of what have often been termed 'strategic' minerals; and, conversely, the consequences that can ensue, particularly under conditions of modern warfare, when such supplies are cut off. There are, too, other aspects of the question. It should, for example, be a matter of much greater concern than it seems to be in Britain that, having extensive coal reserves, the nation seemingly prefers to import coal from abroad rather than make full use of them. Certain aspects of mineral economy have indeed received much publicity lately in Britain, notably the search for sources of the minerals used in the development of atomic energy, and the question of political control in the major oilfields.

Apart from coal, oil and the ores of such well-known metals as iron, copper and aluminium, there are many other minerals, metallic and non-metallic, which are essential for the highly developed chemical, engineering and metallurgical industries, and also for agriculture and food production. There are, too, a number of little-known metals, such as titanium, zirconium, germanium and rhenium, which already play an important part in industry, or are likely to do so in the near future. The author discusses the mineral resources of the world, both geographically and statistically, and the economic, social and political consequences that arise from their uneven distribution.

This is a thoughtful book, which should appeal to all whose interests extend beyond the borders of pure science. V. A. EYLES

WILLIAM BUCKLAND (1784–1856)

By J. M. EDMONDS

Department of Geology and Mineralogy, University of Oxford

AUGUST 14 of this year marks the centenary of the death of Prof. William Buckland, D.D., F.R.S., sometime reader in mineralogy and in geology in the University of Oxford and also Dean of Westminster Abbey. As the sponsor of the 'glacial theory' in Britain, he opened up a completely new field to physiographical investigation; he was among the first to recognize the comparatively late geological date of the great upward movement of the Alps; he described the fossil reptile, *Megalosaurus*, from Stonesfield, Oxon, and he illuminated a large variety of geological and palæontological problems by his researches.

It was after taking his B.A. degree at Oxford in 1804 that Buckland began to attend the lectures of Prof. John Kidd on mineralogy and chemistry, and those of Sir Christopher Pegge on anatomy, while, during the vacations, he searched out the field-evidence which was then being gradually brought together in order to establish the geological succession of strata, scarcely known at that time even in outline. In 1813, Buckland followed Kidd as reader in mineralogy in Oxford, and the success of his courses was such that, on the intervention of the Prince Regent, a readership in geology was endowed in 1818, and to this Buckland was also elected.

When Buckland delivered his inaugural lecture, "Vindiciæ Geologicæ", in 1819[1], the chief challenge to him as a theologian was to reconcile the evidence revealed by the young science with the accepted teachings of the Scriptures. He set out the facts as he saw them, which supported his belief in the 'Mosaic records', but introduced the hypothesis that there was an undefined period of time before the last great change that affected the surface of the Earth and before the creation of its present animal and vegetable inhabitants, a period during which a long series of operations and revolutions were going on "wholly unconnected with the history of the human race". Four years later, he adopted the same point of view in his first major work, "Reliquiæ Diluvianæ"[2], which was essentially a record of his own exploration and excavation of caves with a description of the animal remains found in them. To this was added an account of the 'diluvial' deposits (surface gravels, sands and loams). These he linked in date to the cave deposits by means of the fossil content of elephant, rhinoceros, hippopotamus, bear, tiger and hyæna, which are no longer present in Britain but which were shown by him to have inhabited the country with more familiar animals in 'antediluvian' times.

There is no continuous record of the modifications which came to Buckland in his interpretation of this problem, which so limited the horizon of contemporary thought. There seems to have been no fundamental change in his views in regard to the origin of the surface deposits by 1836 when he published "Geology and Mineralogy considered with Reference to Natural Theology"[3], although he now ascribed them to causes distinct from "the comparatively tranquil inundation described in the Inspired Narrative".

The accounts of grooving and scratching of surfaces of solid rock by the movement of boulders (believed to have been carried along by water) had long been known to Buckland, and he had himself observed that these markings showed some alignment in particular localities. In 1838, he was shown polished, striated and furrowed surfaces and transported granite boulders by Louis Agassiz in Switzerland, where they were attributed by the latter to the agency of ancient glaciers. When he had confirmed the explanation by means of an independent examination of existing glaciers in the Alps, Buckland began to relate it to similar phenomena in Scotland and northern England. At the Glasgow meeting of the British Association in 1840, Agassiz described the action of glaciers and the deposits associated with them, and then he accompanied Buckland to examine the evidence for former glaciation in Scotland. Soon they returned to London to present their findings to the Geological Society, of which Buckland was then president. Their exposition, together with a paper by Lyell (whom Buckland converted after the Glasgow meeting), was the introduction of a new theory regarding the origin of much of the surface deposits covering Britain, and Buckland went so far as to assert[4]: "The subject appears to me the most important that has been put forth since the propounding of the Huttonian Theory: and the surface of the whole Globe must be examined afresh with the view of ascertaining how far the effect of Glaciers and Ice-bergs and of Floods produced by melting ice and snow can be found and identified with the actual effects of ice and snow in our present polar and Alpine regions".

It is probable that Buckland's most important contribution to geology was his ability to present palæontology and the past history of the Earth in such vivid terms. In the "Bridgewater Treatise" and in his lectures, fossils were no longer treated as markings on stones or even as the dead remains of unknown animals; they became the key to the understanding of the sequence of past inhabitants of the Earth. An impression of a footprint on a slab of rock could disclose the size, attitude and even the shape of an animal; a tooth show how a creature lived; coprolites reveal the shape of the intestines and the undigested fragments of the food.

At first in Oxford and later among wider audiences, his lectures aroused remarkable enthusiasm:

> "In Ashmole's ample dome, with look sedate,
> 'Midst heads of mammoths, heads of Houses sate;
> And tutors, close with undergraduates jammed,
> Released from cramming, waiting to be crammed."

The registers show that in 1819, immediately after his inaugural lecture, the Vice-Chancellor and the Junior Proctor paid the statutory fee for the course on the elements of geology. Among the young men were Charles Lyell and John Henry Newman (later Cardinal). In 1823, Buckland wrote to a correspondent: "I have this day been occupied in lecturing to an overflowing class amongst whom I reckon the Bishop of Oxford & 4 other Heads of

Colleges, and 3 Canons of Chch [Christ Church] on the newly discovered Caves. . . .".

In 1845, Buckland was appointed Dean of Westminster, and although he still travelled to Oxford to give his lectures, the popularity of the subject had declined in the University and the numbers attending his courses had fallen to an average of ten persons. The efforts of the scientific professors had for some time been bent towards the inclusion of the natural sciences among the subjects in which undergraduates might be examined for a degree, and Buckland had earlier been prominent in support. The recognition was won in 1850, but in its final stages it came without Buckland's backing, for in 1847 he refused to add his signature to a memorial, prepared by some of his scientific colleagues, asking for a building to house the natural science teaching collections and to contain lecture rooms for the professors. His reasons for his refusal to sign were rather an expression of despair than of lack of regard: "Some years ago I was sanguine, as you are now, as to the possibility of Natural History making some progress in Oxford, but I have long come to the conclusion that it is utterly hopeless".

Whatever were his disappointments in his own University, Buckland attained a high position in the scientific world outside. The Royal Society, the British Association, the Geological Society all provided him with a forum, and he was prominent in support of agricultural, civil engineering and archæological societies. He lectured, entertained and travelled widely, and his friendship with Sir Robert Peel gave him access to a wide and influential circle. With Prof. Adam Sedgwick and Charles Lyell, he prepared the report which resulted in the formation of the Geological Survey of Great Britain, and he later helped towards the establishment of the School of Mines and the Mining Records Office.

As Dean of Westminster, Buckland found his abilities diverted into an entirely different channel of service in the maintenance of the functions and the fabric of a great religious house. He made many improvements in the precincts of both Abbey and School just before the cholera epidemic of 1849, and on the day of thanksgiving for its ending he preached a sermon which was a remarkable plea for sanitary reform in London. He contrasted the cholera-ridden city with the towns of Nottingham and Newcastle upon Tyne, to which water had just been brought; and with Birmingham, "standing on a salubrious rock of clean and filtering porous sandstone". He included a demand for "one grand comprehensive system for a general supply of fresh water near to every house", and "a simultaneous removal of all impurities at the moment of their production, by means of a combined and systematic arrangement of sewage".

[1] "Vindiciæ Geologicæ; or the Connexion of Geology with Religion Explained" (Oxford, 1820).

[2] "Reliquiæ Diluvianæ; or, Observations on the Organic Remains contained in Caves, Fissures, and Diluvial Gravel, and on other Geological Phenomena, attesting the action of an Universal Deluge" (London, 1823).

[3] No. 6 of the Bridgewater Treatises: "On the power, wisdom and goodness of God, as manifested in the Creation".

[4] Manuscript notes quoted by W. J. Sollas in his inaugural lecture, "The Influence of Oxford on the History of Geology" (Oxford, 1897).

THE BIOLOGY OF OLD AGE*

By Dr. ALEX COMFORT

Department of Zoology, University College, London

CONTROL over the rate of human ageing and the transmutation of elements are long-standing and closely associated human ambitions. They have at various times been considered by scientists as a leisure occupation, pursued by magicians and charlatans, or regarded as fundamentally impossible. The second has now been achieved by physicists, though in circumstances far from its traditional context; the first may well be the next major problem to be attacked by medical biology.

Much of the work necessary to increase our knowledge and control of age processes is descriptive and clinical, but the whole problem poses many extremely important questions in general biology, and involves the collection of data in very diverse fields, both descriptive and experimental. A detailed bibliography of the work summarized in this article has been published[1].

The general theories devised in the past were commonly based on the assumption that senescence must involve a single 'fundamental' cellular or chemical process common to all multicellular organisms, and contrasting with the unfortunately named 'potential immortality' of protozoa. None of these assumptions can now remain unquestioned—it seems very probable that there are many multicellular animals which are capable of indefinite cell replacement without loss of vitality, while in some unicellular organisms such as suctorians, where mother and daughter cells are clearly identifiable at fission, the age status of the fission products is not identical, and individuals have a fixed life-span which can be modified experimentally[2]. It is probably wise to assume that, in those animals where vigour does decline with age, the responsible processes are multiple, and to treat senescence as the sum of all those factors—from mechanical wear of teeth or chitin to more complex endogenous changes—which progressively impair homœostasis. A general definition of this kind, as well as being convenient, is theoretically justified by the place which senescence seems to occupy in evolution[3,4]. In a population subject to the high mortality which is common to many animals in the wild, the evolutionary relevance of individuals, and hence the selection-pressure towards vigour and homœostasis, probably decline very rapidly with increasing age: the common feature of all ageing processes in animals may be that they represent a 'running out of programme', and an escape from the selection pressures which maintain fitness at the ages when contribution to the next generation is greatest. One manifestation of this may be the failure to eliminate late-acting lethal genes, for where individuals very rarely reach even

* Substance of a Friday Evening Discourse delivered at the Royal Institution, London, on June 1.

mid-adult life unless protected, the postponement of an adverse effect is as effective an adaptation as its removal. If this is so, we might expect the processes which limit the lives of different animals to be diverse. At the same time, in view of the general similarity of animal cells throughout phylogeny, the likelihood that some deteriorative processes at the cellular level are shared by all animals whose powers of regeneration are incomplete is sufficient to justify wide comparative study.

Animal Life Tables

By far the best measure of senescence in a population of organisms is their liability to die at different ages. If we had a full account of the relation between growth, age and mortality in a sufficient range of representative animals, the truth of many existing general theories of senescence could probably be tested by inspection. Those actuarial studies which we have suggest an inverse relationship in phylogeny between degree of cell-replacement and liability to senile change. Thus death from old age in rotifers and nematodes, where the cell number is fixed, is sudden and unanimous, with obvious cellular change, whereas in sea anemones the cell turnover is probably continual, and they appear to remain indefinitely vigorous.

It is particularly important now to obtain accurate actuarial figures for the main types of vertebrates. Although typical senescence, with a sequence of changes similar to that in man, almost certainly occurs in all mammals and birds, the longevity of birds is strikingly greater than that of mammals of comparable size and activity (29 years in a chaffinch, compared with 3–4 in a mouse), and there are large differences between closely related species. It is also by no means certain that all poikilothermal vertebrates do in fact undergo any marked change in mortality with age, beyond that resulting from the accumulation of evident injuries. It has been suggested that the particular type of ageing found in mammals is in some way connected either with homoiothermy, or with the evolution of a fixed specific size. Bidder[5], from work on the continued growth of plaice at high ages, put forward the theory that senescence in its mammalian form is the direct result of growth-inhibitory mechanisms evolved during the transition to life on land to limit adult size, and that it does not occur in fish or reptiles which grow continuously, or remain capable of doing so.

In view of hypotheses like these, one of the main preoccupations of comparative research on ageing is the collection of animal, and particularly vertebrate, life tables, based on animals living under conditions of captivity sufficiently good for a fair proportion of them to reach old age. So far as can be ascertained, no life table based on a captive population has ever been published for any fish, reptile or amphibian. The longevity of many small species (14 years in frogs and 25–30 in newts) makes it almost impossible to seek experimental data directly. One incomplete life table exists for domestic poultry[6], and this is constructed on an assumed equation. Apart from these, we have satisfactory actuarial data only for man, laboratory rats and mice, and a few other rodents (*Microtus*[7,8], *Mastomys*[9]), with partial figures for a few agriculturally important animals (for example, merino ewes[10]). No general view of mammalian age processes can yet be obtained, and in view of the time necessary to follow experimental populations, the deficiency can be remedied only by the unearthing of already existing data. The possible value of such information in comparing the life-spans of similar animals, in correlating patterns of growth and of age-mortality, and in the criticisms of general theories of ageing is still not sufficiently widely appreciated. Actuarial figures for all the main breeds of dog, for example, would be of great interest. Workers who normally keep large animal populations, or who have suitable records, could help greatly in this work by bearing these needs in mind. The same applies to accurate data on maximum life-spans: the quality of the information available was greatly improved by the work of Flower, but many, if not most, of the commonly quoted figures are still based on legend.

Studies on specially kept populations of small aquarium fish have demonstrated a pattern of senescence which, in the guppy (*Lebistes*), is very similar in its time-scale to that of laboratory rats (median $\simeq$ 500 days, limit $\simeq$ 1,200 days), and which occurs at a rather similar rate in both sexes, although the adult size of the males is fixed by growth cessation early in life, while the females may continue to grow at any age. This fish is particularly suitable for experimental work on poikilothermal growth and ageing, since it readily survives handling, and its growth can be precisely controlled by altering its food intake and living space. We are taking advantage of these properties in a number of experiments to study the effect of age and of various growth regimes on the force of mortality in a poikilotherm.

Cytology

There are a number of cytological problems, quite apart from descriptive pathology of senile changes, which should be susceptible to investigation. One of these, in view of the correlation which appears to exist between senescence and cessation of cell division, is the sequence of changes which limits the life of non-dividing cells. Some of these changes, like those in rotifers, occur visibly and should be accessible to microchemical and enzyme studies.

It is probably true that the life-span of all fixed postmitotic cells is limited in terms of molecule turnover. Spoilage of enzyme systems in such cells probably accounts for the senescence of animals the cell number of which, as in rotifers, is strictly determinate. A similar process in cells such as neurones might play a part in the senescence of vertebrates; but very little is known of the life-span and replaceability of any tissue cells *in situ*, and it is quite possible that in higher animals which senesce there is a change in the quality and responses of successive cell generations.

The question whether changes due to faulty copying are inherent in clones, and if so whether metazoan bodies are analogous to other clones in this respect, was asked long ago by Maupas, and cannot yet be answered with certainty, except to the extent that there are apparent instances among plants and protozoa of both stable and unstable clones. Recent work by Sonneborn and his school has shown that the degeneration of clones of *Paramecium* is probably due to uneven distribution of the chromosomes of a highly polyploid macronucleus between daughter cells. This process is presumably peculiar to ciliates; it might be that something similar occurs in somatic cells, or in some of them,

through distribution of cytoplasmic structures, or through aneuploidy, but there is so far no evidence that this is a factor in metazoan ageing.

Another relevant question is the effect of cell division on the age-status of the fission products. The fact that suctorians have a demonstrable life-span has already been mentioned. It would be interesting to know whether in cases where one fission product receives a newly formed and the other a pre-existing organelle, this difference confers any difference of viability. The assumption that in any fission without differentiation the daughter product is a pair of cells equal in age status may require re-examination, both in acellular organisms and possibly, by photographic means, in tissue cultures. The construction of life tables for various mammalian somatic cells, by labelling techniques such as are now used *in situ* for red blood cells, is also probably not out of the question, and would be well worth the attempt.

Experimental Physiology and Genetics

In 1935 McCay[11] and his co-workers showed that rats which were kept in a juvenile condition by calorie restriction could be restarted in growth at ages up to and even a little beyond a thousand days, and that the period of retardation represented a true postponement of the senile increase in mortality, the life-span being increased by that amount. This is perhaps the most important piece of information so far; but although it is twenty years old, little more has been done to determine which components of development must be retarded in order to slow down ageing. Dietary restriction after puberty lengthens the life of rats, but only by a much smaller amount: intermittent fasting (one day in three) and restriction of diet (short of preventing growth)[13] have both been found to lengthen the life of rats; but in these cases the increase was less striking, and more closely related to the avoidance of surfeit diseases than to developmental slowing.

An incidental implication of McCay's work is that the optimal dietary intake for human growth in childhood might not be that which produces the longest total life span. McCance and Widdowson[14] and Sinclair[15] have suggested that by pursuing rapid growth in childhood dietitians might be shortening the plateau which normally occurs in the human prepubertal growth curve, and possibly reducing the life-span, either by that amount or even by more. The age of puberty in Western countries is said to have shown a substantial advance over the past century. Maturity, judged both by the date of the menarche in girls[16] and the age of maximum stature in boys[17], has advanced in that time by as much as seven years. This may possibly represent a reversion to an older pattern which had been disturbed in the 1800's, and its cause is unknown, although diet, better economic and social conditions, and heterosis due to a reduced degree of inbreeding have all been invoked. Life statistics cannot be used to determine whether earlier development has altered the rate of ageing, since the gain in expectation of life from medical science is much larger than the loss which might be expected. Where rapid development is genetic in origin it is usually a character of vigour, and in human congenital precocious puberty, where menstruation may begin at the age of two or three years, the expectation of menstrual life is greater, and that of total life no less, than in normally timed individuals[18]. This might not be true of dietary acceleration: the optimal rate of human development is difficult to establish, but it seems that we may still need to establish it.

The only experimental procedures which can at present produce increases in mammalian life-spans equal to those due to dietary restriction are genetic. There is a correlation between human parent and child longevities, but it is only a quarter of that for stature[19]. The life-span of laboratory animals can be increased by eliminating specific heritable disease, but the tendency of inbred stocks is to reach a stable life-span shorter than that of random-bred animals[20,21]. This can be increased, and sometimes doubled[22], by hybridization, though probably not beyond the figure for fully heterozygous 'wild' individuals of the same species (direct comparison with wild-caught stock is greatly complicated by other factors). The mechanisms responsible for the vigour of hybrids may prove significant in studies of ageing: the differences between hybrid and inbred animals are in some ways similar to those between young and old, especially the low variance of many characters in hybrids and their greater resistance to outside disturbance[23,24]. Both old and inbred animals appear to have a diminished repertoire of responses to biological stresses. It should be instructive to analyse this similarity in specific cases.

Apart from these questions, there is a rapidly growing range of methods which can now be used to study ageing along the lines of classical experimental physiology. The improvement of grafting techniques and the knowledge of their limitations make it possible to create age chimeras, the use of these being to study the mutual interaction of host and graft of different ages, rather than in the first instance the endocrine effects of young grafts on ageing animals, as in the past. It is also possible through the use of storage techniques to re-implant tissue taken from infant animals in the same animals when they are old. The obstacles to larger experimental procedures of this kind are chiefly problems of tissue compatibility—the surgical techniques available already permit work such as the complete transplantation of heart–lung preparations in dogs, and their exchange between animals, carried out routinely by Demichov at the Vishnevsky Institute; the survival of these large-scale transplants is limited only by the homograft reaction. Ingenious ways of overcoming this in specific cases, such as the intra-embryonic injection of cell antigens recently described by workers at University College, London[25], might eventually make possible the creation of very extensive age chimeras. Organ culture, which has been relatively little pursued since the early work of Carrell, offers yet other possibilities in this direction.

Classical methods can also be applied to the endocrinology of ageing, with the powerful reinforcement of paper chromatography. Much previous work in this field may have been based on false assumptions, and it now seems decreasingly probable that mammalian age changes will prove controllable by hormones alone, even when more of them are available: the most promising in this field may prove to be those controlling protein anabolism. The endocrinology of timing mechanisms—in particular, those affecting puberty and the menopause—is of great importance, and is already under examination. The second of these is complicated by the lack of laboratory animals which follow the human pattern; the first offers some promise of finding a developmental

timekeeper in the central nervous system, which might open very wide fields of investigation.

To those engaged in any of these studies, however, the main requirement of progress is a wide awareness among biologists in general of the nature and scope of the problems which age studies raise, since only through this will the additional information we need be forthcoming.

[1] Comfort, A., "The Biology of Senescence" (Routledge and Kegan Paul, London, 1956).
[2] Rudzinska, M., *Science*, **113**, 10 (1931).
[3] Haldane, J. B. S., "New Paths in Genetics" (London, 1941).
[4] Medawar, P. B., "An Unsolved Problem of Biology" (H. K. Lewis, London, 1952).
[5] Bidder, G. P., *Nature*, **115**, 495 (1925); *Brit. Med. J.*, ii, 5831 (1932).
[6] Gardner, G., and Hurst, H., *Proc. Utah Acad. Sci.*, **10**, 149 (1933).
[7] Leslie, P. H., and Ranson, R. M., *J. Anim. Ecol.*, **9**, 27 (1940).
[8] Leslie, P. H., Tener, J. S., Vizoso, M., and Chitty, H., *Proc. Zool. Soc., Lond.*, **125**, 115 (1955).
[9] Oliff, W. D., *J. Anim. Ecol.*, **22**, 217 (1953).
[10] Kelley, R. B., *Aust. Vet. J.*, **15**, 184 (1939).
[11] McCay, C. M., in Lansing, A. I., "Problems of Ageing" (Williams and Wilkins Co., Baltimore, 1952).
[12] King, J. T., and Visscher, M. B., *Fed. Proc.*, **9**, 70 (1950).
[13] McCance, R. A., and Widdowson, A. M., Ciba Found. Colloq. Ageing, **1**, 186 (1955).
[14] Sinclair, H. M., Ciba Found. Colloq. Ageing, **1**, 194 (1955).
[15] Tanner, J. M., "Growth at Adolescence" (Blackwell, Oxford, 1955).
[16] Morant, G. M., *Proc. Roy. Soc.*, B, **137**, 443 (1950).
[17] Jolly, H., "Sexual Precocity" (Blackwell, Oxford, 1955).
[18] Beeton, M., and Pearson, K., *Biometrika*, **1**, 50 (1901).
[19] Pearl, R., and Parker, S. L., *Amer. Nat.*, **56**, 174 (1922).
[20] Comfort, A., *Nature*, **172**, 83 (1953).
[21] Clarke, J. M., and Maynard Smith, J., *J. Genet.*, **53**, 172 (1955).
[22] Grüneberg, H., *Nature*, **173**, 674 (1954).
[23] McLaren, A., and Michie, D., *Nature*, **173**, 686 (1954).
[24] Billingham, R. E., Brent, L., and Medawar, P. B., *Nature*, **172**, 603 (1953).

OBITUARIES

Dr. John Wishart

Dr. John Wishart, reader in statistics in the University of Cambridge, was born in Perth on November 28, 1898, and was educated at Perth Academy and the University of Edinburgh, where he was one of the many able mathematicians taught by Sir Edmund Whittaker. After leaving Edinburgh he spent two years teaching at Leeds, and then went in 1924 to the Galton Laboratory at University College, London, as research assistant to Prof. Karl Pearson. He stayed there three years, and after a brief period at the Imperial College of Science and Technology, joined the staff of the Rothamsted Experimental Station in the statistical department just at the beginning of its great period of expansion under Sir Ronald Fisher's inspiring leadership. He made his mark there, and left to become reader in statistics at Cambridge in 1931. During the Second World War he served as a captain in the Intelligence Corps during 1940–42 and was a temporary assistant secretary at the Admiralty during 1942–46. He was a Fellow of the Royal Statistical Society, of the Institute of Mathematical Statistics and of the American Statistical Association, a member of the International Institute of Statistics, and an associate editor of *Biometrika*.

To one who was associated with him from the earliest days and in all three places where his life-work was done, the tragedy of his early death at the age of fifty-seven is only too apparent. He was drowned in a bathing accident in Mexico on July 14, during a visit to Central America on behalf of the United Nations Food and Agriculture Organization, to organize a research centre for the teaching of statistics in agricultural research.

Wishart was the author of three books on field experimentation and many research papers on mathematical statistics in scientific journals. His scientific work was characterized by exceptional accuracy and attention to detail, with which he combined more than usual organizing ability. The first of these characteristics was shown in his earliest papers on the numerical computation of certain integrals; the second became manifest at Rothamsted, where he helped with the organization of field experimental programmes and for several years carried out most of the statistical analysis. His best-known paper, produced at Rothamsted, was concerned with what came to be known as the 'Wishart distribution'. This is the generalized product moment distribution in samples from a multivariate normal population. Another of his main theoretical interests was the development of explicit formulæ for the cumulants of 'k statistics' using Fisher's combinatorial methods. This subject formed an important part of the lectures which he gave at Cambridge, and he returned to it as late as 1952.

Wishart was at his best in the years 1931–39, when as a result of his teaching at Cambridge, the modern statistical outlook was adopted by a number of Cambridge mathematicians who took up statistics as a career. They spread the knowledge of statistics as a scientific subject and did much to set up a chain-reaction which still continues. Their training made them aware of the almost unlimited potentialities of statistical methods in many diverse fields, and there is still no sign of diminishing *tempo* in their application.

J. O. Irwin

Prof. E. A. Braude

By the sudden and untimely death on July 23 of Prof. E. A. Braude we have lost one of the most brilliant and most active of our younger organic chemists.

Ernest Braude was born in Germany in 1922, came to Britain as a boy of fifteen, and was naturalized at the age of twenty-four. His British education started in private schools and at Farnham Grammar School. He spent one year at Birkbeck College before going to the Imperial College of Science and Technology, where he spent virtually the rest of his academic life. He graduated with first-class honours in chemistry in 1942, receiving the Acland and Frank Hatton Prizes. He spent the next three years as research assistant to Sir Ian Heilbron, became an assistant lecturer in organic chemistry in 1946, lecturer in 1947 and reader in 1952. He succeeded to the chair of organic chemistry in 1955. In 1950 he received the Meldola Medal of the Royal Institute of Chemistry and the D.Sc. of the University of London.

Braude published his first original papers at the age of twenty-two, and in the next twelve years, up to the time of his death, a flow of research memoirs followed, remarkable both in quantity and in the very high standard maintained. In his earlier years he worked in collaboration particularly with Dr. (now Prof.) E. R. H. Jones, and more recently, in

studies of hydrogen transfer, with me. He had a number of enthusiastic junior collaborators, including many from overseas. The names of Stern, Timmons, Waight, Jackman and Forbes come to mind. To all his work he brought deep knowledge, sound judgment and enthusiasm, and he was particularly generous in giving helpful advice on other research going forward at the Imperial College.

He was remarkable for the range of his interests. He did valuable work on the synthesis of hydroaromatic and condensed benzenoid systems, particularly in the direction of vitamin D. He was responsible for a new synthesis of thiooctic acid. He made important studies of molecular rearrangements, particularly of anionotropy. But he will probably be best remembered for his great knowledge of, and contribution to, the methods of organic chemistry. He discovered the lithium alkenyls and illustrated their synthetic value; he made most significant contributions to the methods of hydrogen transfer processes and their interpretations; and above all he was a master in the application of methods of light absorption to the elucidation of structure and reactions. It was his expert knowledge in this and allied fields which made the book "The Determination of Organic Structures by Physical Methods", which he edited with Nachod, of such great value.

Braude was an extremely clear and conscientious teacher and was in great demand at scientific meetings. He had travelled and lectured in many countries. He was happily married, a most valued colleague and a kind friend. His sudden death at the height of his creative powers, so soon after obtaining a leading academic position, is a matter for profound regret and leaves a great sense of loss.

R. P. LINSTEAD

NEWS and VIEWS

Presidency of the Canadian Association of Physicists: Dr. G. Herzberg, F.R.S.

DR. GERHARD HERZBERG, director of the Division of Pure Physics of the National Research Council of Canada, has been elected president of the Canadian Association of Physicists. Dr. Herzberg was born in Hamburg in 1904 and studied physics at the Darmstadt Institute of Technology. During 1928–30 he did postdoctorate work at the University of Göttingen and at the University of Bristol, and then for five years was an assistant in the Department of Physics at the Darmstadt Institute of Technology. He joined the staff of the University of Saskatchewan as research professor of physics in 1935 and became professor of spectroscopy at the Yerkes Observatory of the University of Chicago in 1945. He returned to Canada three years later as principal research officer with the National Research Council at Ottawa, becoming director of the Council's Division of Physics in 1949 and director of the Division of Pure Physics in 1955. Dr. Herzberg has contributed to the knowledge of the structure of a number of important molecules, including molecular oxygen, molecular nitrogen, carbon dioxide, acetylene and hydrogen cyanide; and he has discovered several new molecules, such as phosphorus nitride and phosphorus carbide. By comparison with his laboratory spectra, it has been possible to establish the presence of certain molecules in planets, stars and in the interstellar space; for example, molecular hydrogen has been detected in the atmosphere of Uranus, and the presence of a diatomic molecular ion consisting of carbon and hydrogen in interstellar space has been demonstrated. Recently Dr. Herzberg and his collaborators have carried out work on the spectra of free radicals. In 1953, he was awarded the Henry Marshall Tory Medal of the Royal Society of Canada "for his achievements in the field of atomic and molecular spectra".

Mechanical Engineering at Sheffield: Prof. J. P. Duncan

MR. J. P. DUNCAN, who has been appointed to the new chair of mechanical engineering in the University of Sheffield, was educated at Scotch College, South Australia, and then at the University of Adelaide, graduating in engineering in 1941. During 1940–46 Mr. Duncan was a student apprentice with Richards Industries, Ltd., a company closely associated with the Chrysler Corporation of the United States. After training in all phases of the company's activities and a period spent in the United States, he afterwards held the executive posts of assistant superintendent of aircraft production and assistant development engineer; in the latter capacity he was for a time solely responsible for the design of post-war motor bodies built in Australia under contract to British and American firms. During 1947–54, Mr. Duncan was on the staff of the University of Adelaide with a primary responsibility for the design and layout of equipment in a new school of mechanical engineering, and in 1954 acted as head of this department. In 1952 he spent one year of study leave in the steam turbine and mechanical research departments of Metropolitan-Vickers Electrical Co., Ltd., and conducted researches into several problems associated with steam power plant, on which he has since published several papers. He returned to England in 1955 as a Turner and Newall Research Fellow for the purpose of extending these researches, and is at present lecturer in mechanical engineering design in the University of Manchester. Mr. Duncan's general interests are in experimental stress analysis, machine design and engineering economy. A special interest is the mechanical design of heat exchangers, in which he is developing optical interference as a method of studying the bending of multiply connected elastic tube-plates.

Acoustics at Newcastle upon Tyne: Prof. E. G. Richardson

DR. E. G. RICHARDSON, who has been appointed professor of acoustics at King's College, Newcastle upon Tyne (University of Durham), has been on its staff for many years. He joined as lecturer in physics in 1931 and became a reader in 1943. During the Second World War, he did important research in acoustics for the Admiralty and in aerodynamics for the Royal Aircraft Establishment. Always interested in the literary side of science, he has written a standard text-book on sound which is now in its fifth edition, together with others on architectural and musical acoustics, ultrasonics and on science for the layman. He is British editor of the international journal *Acustica* and general editor of a large work

on technical acoustics, the contributors of which include authorities from most countries of the scientific world. His researches cover a wide field in acoustics, ultrasonics, aerodynamics and rheology, and his published work amounts to about one hundred papers. Prof. Richardson, who has lectured in France, Belgium, Italy and Egypt, has recently returned from the United States and Canada, where he has been attending conferences and visiting acoustic laboratories as a consultant. In his new chair, he is commencing an ambitious programme of research, and at the moment, as holder of a Leverhulme fellowship, is particularly interested in meteorological and marine acoustics.

Department of Scientific and Industrial Research Bill

In presenting in the House of Lords on July 23 the House of Commons amendments to the Department of Scientific and Industrial Research Bill, the Lord President of the Council, Lord Salisbury, said that they are all clarifying amendments relating to Sub-section (3) of Clause 1. The first secures specific mention of technical colleges as places in which the Advisory Council may encourage and support scientific research, and Lord Salisbury said that it has always been the intention of the Government that they should be so covered. The second relates to what may be called, in general terms, development work; and this likewise is intended by the Government to be within the orbit of the new Council, as it is indeed within that of the Department of Scientific and Industrial Research to-day. The third amendment is designed to make it clear that the Council can take account of what is being done elsewhere; although it is not intended or desired that the new Council should attempt to organize and co-ordinate all the scientific and industrial research in Britain, it is intended that, in planning the Department's research programme, the Council should have regard to the total picture of the country's research effort. In commending this amendment, Lord Salisbury also added that, while the amendment should help to ensure that unnecessary overlapping would be avoided, it is left open for the Council to engage in some particular line of research already being pursued elsewhere, if for some special reason it is desirable to do so. The amendments were agreed.

Agricultural Improvement Council for England and Wales

The Agricultural Improvement Council, which recently reached the end of a further three-year period of office, has been reconstituted by the Minister of Agriculture, Fisheries and Food. The Council, which was set up in 1941, keeps under review the progress of research and improvements in technical methods so as to ensure that promising results are applied as rapidly as possible to agriculture and horticulture and to commercial practice in these fields, generally, and advises the Minister from time to time on agricultural and horticultural problems which appear to require scientific investigation and on general policy whereby production may be increased. The reconstituted Council is as follows: Sir Alan Hitchman (*chairman*), permanent secretary, Ministry of Agriculture, Fisheries and Food; Sir Frank Engledow (*vice-chairman*), Drapers' professor of agriculture, Cambridge; Captain J. F. Bomford, farmer and market gardener; Harold Collison, general secretary, National Union of Agricultural Workers; H. R. Finn, farmer, Canterbury; E. Gibby, farmer, Pembroke Dock; Prof. K. Mather, professor of genetics, Birmingham; J. W. S. Mount, horticulturist and farmer, Canterbury; the Duke of Northumberland, landowner and farmer; H. J. Rathbone, chartered land agent, Mold; F. Rayns, director of the Norfolk Agricultural Station, Sprowston; Prof. Ellis J. Roberts, professor of agriculture, Bangor; Sir James Scott Watson, formerly chief scientific and agricultural adviser to the Minister of Agriculture and Fisheries; Sir William Slater, secretary, Agricultural Research Council; H. Cole Tinsley, farmer, Peterborough; Sir James Turner, president, National Farmers' Union; Prof. T. Wallace, director, Long Ashton Fruit and Cider Research Station; and Prof. E. G. White, professor of veterinary preventive medicine, Liverpool. The secretary of the Council is W. Morley Davies, senior education and advisory officer, Ministry of Agriculture, Fisheries and Food, Great Westminster House, Horseferry Road, London, S.W.1.

Tobacco Manufacturers' Standing Committee

The formation is announced of the Tobacco Manufacturers' Standing Committee, composed of representatives of the Federation of Home and Export Tobacco Manufacturers, British–American Tobacco Co., Ltd., and the Imperial Tobacco Co. (of Great Britain and Ireland), Ltd. This development gives formal status to the co-operation in research of the group of manufacturers which in 1954 made a donation of £250,000 to the Medical Research Council for investigation into the causes of lung cancer. Sir Alexander Maxwell will be chairman of the Committee and Sir Alfred Egerton and Sir Ronald Fisher have consented to act as scientific consultants to the Committee in the fields of physical chemistry and statistics, respectively. It is intended in due course to invite authorities on other subjects to serve in a consultative capacity. The offices of the Committee will be at 6–10 Bruton Street, London, W.1.

Technical Education Courses in Britain

In a written statement given in the House of Commons on July 24 about arrangements for regional co-ordination of technical courses and inter-authority payments, the Minister of Education said that he had met representatives of the London County Council and of the Associations of Local Authorities and Education Committees on July 17 and that they had agreed to make certain recommendations to their constituents. In the light of the White Paper on Technical Education and Circular 305 of the Ministry, the local education authorities should invite regional advisory councils to examine urgently the existing provision of vocational courses and to consider how far industry and employers generally are aware of the provision already made for technical education, and how industry and the technical colleges can be better informed of any decisions resulting from a regional advisory council's advice which may affect the pattern of future development and particularly the planning of new advanced vocational courses. A working party of officers of the Ministry, H.M. inspectors, representatives of local authorities and education committees (including representatives of technical colleges), representatives of industry and officers of regional advisory councils should be set up to consider procedure for examining and approving, in the first instance, technical education courses. Authorities should give automatic consent to the

attendance of students at any advanced courses at a designated college of advanced technology outside the area in which they reside and also in respect of attendance at any other course in a designated college or elsewhere, except where an authority finds it desirable to require prior consent. The Minister and the regional advisory council concerned should be informed of the exceptions. Automatic consent may be withdrawn if, in the authority's opinion, the student's attendance or progress is unsatisfactory. Local education authorities should review the composition of governing bodies of technical colleges to ensure that they include appropriate representation of authorities from whose areas substantial numbers of out-county students are drawn.

International Radio Consultative Committee

THE eighth plenary assembly of the International Radio Consultative Committee (C.C.I.R.) was formally opened in Warsaw on August 9, to study various technical problems encountered in the practice and development of radio communication, with the view of making recommendations to be submitted to the International Telecommunications Union (I.T.U.). The work of the Committee is organized under fourteen study groups, which are meeting during the period August 10–31, after which the full assembly will discuss the various recommendations and study programmes with the view of their adoption as a guide to future progress in the radio field. The United Kingdom delegation is led by Captain C. F. Booth, assistant engineer-in-chief, General Post Office, accompanied by seven other delegates of the Post Office staff, and one each from the Department of Scientific and Industrial Research and the Ministry of Supply. The delegation also includes technical advisers of the Radio Industry Council and representatives of the organizations operating radio services in Britain. Two members of the delegation are the international chairmen of study groups, namely, Dr. R. L. Smith-Rose (Study Group V), on tropospheric wave propagation, and Mr. H. Stansby (Study Group IX), which deals with general technical questions.

Among the subjects of particular scientific interest under discussion are those of radio wave propagation over the ground and through the troposphere and ionosphere, atmospheric noise in various parts of the world, radio time signals and standard frequencies and various aspects of broadcasting and television. Adequate liaison arrangements have been established between the International Radio Consultative Committee and the International Scientific Radio Union (U.R.S.I.) for the study of subjects of mutual interest, with the general objective of improving the efficient and economical use of the radio-frequency spectrum for all practical and scientific purposes.

World Resources in the Immediate Future

THE spring issue of *Progress*, the magazine of Unilever, Ltd., includes the last of a series of articles surveying world resources which Sir Solly Zuckerman has edited during the past five issues. The series was introduced by Sir Solly himself in the spring issue of 1955 with an article in which he outlined broadly the problem presented by the rapid growth of world population and the consequent growing demand for capital and consumer goods and higher standards of living. In following articles M. John considered, first, world supplies of power and water and then those of land and food, and finally of raw materials, setting out in broad terms the main material considerations that are likely to determine the development of industry over the next two or three decades. In this final article on the social and political aspects, Sir Solly Zuckerman agrees that no shortage is likely to develop capable of defeating human ingenuity; but he believes that the unequal division of resources between 'have' and 'have-not' countries is the core of a social challenge steadily growing more urgent with the rapid increase in the populations of the under-developed countries of the Eastern world. The price of peace may well be the sharing of resources, and if the British are not to lose by the sharing they must remain constantly alert to the challenge of new industrial technologies and to the possibilities of creating greater wealth.

The Imperial Forestry Institute, Oxford: Report for 1954–55

THE thirty-first annual report for 1954–55 of the Imperial Forestry Institute, Oxford, to which is attached the University School of Forestry (pp. 32; from the Institute, 1956), points out that in 1955 the School celebrated its fiftieth year, having been brought to Oxford by Dr. Schlich when the Royal Indian Engineering College, Coopers Hill, was closed in 1905. The Forest Herbarium, though still housed in the Botany Department, has now been transferred back to the School of Forestry. The number of students attending courses during the year was fifty-eight. Fourteen were successful in the examination for their forestry degrees; and of these, two were Colonial forest probationers who returned to their Colonies, two obtained posts in the Colonial Forest Service, one returned to Pakistan to join the Forest Service there, a South African obtained a post in the Northern Rhodesian Forest Department, and another two went to Canada before returning to South Africa. One government scholar from each of Kenya and Jamaica returned to join their respective forest departments. One graduate joined the Oxford University Expedition to Borneo as botanist, and four joined up for National Service. This enumeration furnishes ample evidence that the Institute has fully justified its inauguration, the more so since many parts of the British Colonies will in future be more or less dependent upon it for maintaining the requisite professional knowledge in the staffs of their departments. The forest officers' course at the Institute was attended by twelve officers of the forest services of various Colonies. The sections dealt with in the report are sylviculture, ecology, tree physiology, forest botany, forest pathology, forest entomology, mensuration, aerial surveys, statistics, forest economics, forest law, Colonial forest administration, forest protection, surveying and the library.

Agricultural Research in India

A BRIEF account of research and agriculture in India under the Second Five-Year Plan is given in the April number of *Science and Culture* by M. S. Randhawa. Out of Rs. 350 crores for the Central and State research and development schemes, Rs. 38 crores is for direct expenditure by the Central Government. The production and distribution of nitrogenous fertilizers is to be increased to three times the present level of 600,000 tons a year, and a scheme is proposed for the distribution of improved seeds through a network of seed farms, each serving a group of a hundred villages. Large-scale developments are proposed for cattle, sheep and poultry,

including an additional three hundred artificial insemination centres and six hundred extension centres for which more than thirty thousand bulls will be required, including 4,200 of known pedigree and productive capacity. Rinderpest is to be eradicated by planned mass-scale vaccination of all cattle throughout the country, and by 1961 the National Extension Service for extending knowledge to the farmer will cover the entire country. In regard to research, Dr. Randhawa stresses the importance of radiobiology, particularly radiogenetics, and the exploitation of hybrid vigour, notably hybrid maize, sorghums and vegetables, and also hybrid poultry and pigs. Provision has also been made for the establishment of two horticultural plant introduction stations at Saharanpur and Hasarghatta; a Division of Horticulture is being established at the Indian Agricultural Research Institute at a cost of Rs. 11,29,000, and regional research is projected on mango, citrus, grapes, guava, apples and pineapples.

Farming Advisory Services in North America

In 1955 a mission, sponsored by the Nuffield Foundation, visited the United States and Canada to study the farming and advisory services in order to gain ideas for increasing the efficiency of the agricultural advisory work in England and Wales. Its report, "Farming Advisory Services in North America", has now been published (pp. 53; from the Nuffield Lodge, Regent's Park, London, N.W.1; 1956; 4*s*. 6*d*.). While fully recognizing the different physical, economic and social factors that influence farming in North America and Great Britain, the report suggests certain changes in the organization of the National Agricultural Advisory Service based on American 'extension' experience. It recommends "that serious reconsideration should be given to the desirability of making it (as in Scotland) an extramural activity of university schools of agriculture. Removal from direct government control would help to give the service a better professional status and to increase the farmer's confidence and co-operation". More encouragement should also be given to developing local interest. To this end, county and rural district councils might contribute to the cost of the service and more use made of the district office, now in danger of being closed. Programme planning with later assessment of results, carried out at the local level, could be a further means of promoting co-operation between the advisory officer and the farming community. The issue of supervised loans at low interest-rates to low-income farmers, similar to those provided under the Farmers Home Administration in the United States, is another suggestion put forward; but it is made clear that the responsibility of any such scheme should not be with the Advisory Service. In conclusion, much of the success of the American 'extension' was felt to be due to the prevailing spirit of confidence, both in itself and between the service and the farmer.

Datura Research Material

The Smith College Genetics Experiment Station was discontinued at the end of 1955, a year after the death of Dr. Albert F. Blakeslee, its founder and director since 1942. For many years the investigations of Dr. Blakeslee and his colleagues at Smith College, and earlier at the Department of Genetics of the Carnegie Institution of Washington, had been concerned with the genetics of *Datura*. As a result of this work, tetraploid, as well as diploid, lines of most species as well as chromosomally different races are available. The National Science Foundation has recently made a grant to Smith College to finance the assembling of the data on the genetics of *Datura* and related problems, and its publication in a monograph on *Datura*. This will be in charge of Amos G. Avery, and the principal contributors will be Dr. Sophie Satin and Dr. J. Rietsema. Seed of all the species and of most of the races and types have been grown and placed in controlled cold storage. These are available to any investigator who desires to continue some aspect of research on *Datura*. Application should be made to Dr. H. H. Plough, Amherst College, Amherst, Mass., indicating the seeds desired and the general nature of the investigation planned.

Cell Mounts for Biological Materials

In an article in the *Museums Journal* (November 1955), Mr. C. V. Adams, of the City Museum, Plymouth, discusses the use of cell mounts as an alternative to embedding biological specimens in transparent plastic. It is maintained that the use of plastic entails several stages in the work and that specialized skill and a fair amount of time are necessary. In cell mounts the material may be mounted in formalin, alcohol or in the dry state. The last is especially useful as it enables many of the Lepidoptera to retain their colour, which is often lost in an embedding process. The mount consists of a transparent polystyrene lid which fits on to the flange of a polystyrene base-plate. The base-plate can be obtained in black, white or completely transparent, and the entire mount measures $2\frac{3}{4}$ in. × $1\frac{1}{2}$ in. × $\frac{1}{2}$ in. When used with a liquid mount, the cell is capable of holding 40 c.c. of preservative. The lid is welded to the base by 'Cristalite'. The cell mounts can be obtained from P. K. Dutt and Co., Ltd., of Alfred Place, London, W.C.1.

Production and Transport of Liquid Methane

At a recent meeting of the Institution of Gas Engineers, J. Burns and L. J. Clark considered the economics of liquid methane derived either from methane itself or natural gas in association with oilfields (Publication No. 484 of the Institution; pp. 22; 1956). It is argued that, in the Middle East alone, more natural gas is being burnt to waste than would be needed to meet the total requirements of the British gas industry. Regarding sources of supply to Great Britain, the Middle East, Mexico and Venezuela are potential areas since reserves are vast and comparatively unexplored, reasonably near seaports and, at present, subject to limited local demand. The chief problem is trans-ocean transport of the liquefied gas which, incidentally, only occupies 1/600 of its volume in the gaseous state. It would require the construction of liquid methane tankers capable of carrying this fluid at sub-zero (Fahrenheit) temperatures; such tankers would have to be of at least 35,000 tons and would be at least double the cost of conventional oil tankers. Storage conditions and costs would also be considerably higher than for oil; further, distribution would be restricted to industrial areas where deep-water facilities are available.

Scottish Soil Survey

The fourth memoir to be published of the Soil Survey of Great Britain, and the second concerning Scotland, has appeared under the title "The Soils of the Country round Jedburgh and Morebattle" (pp.

178. Edinburgh: H.M.S.O. 30*s*.). The area surveyed embraces Sheets 17 and 18 of the 1 inch/1 mile Geological Survey of Scotland. Sheet 18 comprises only a small corner of Scotland, the rest being left blank, presumably to be completed in due course by the Soil Survey of England and Wales. It would have been more convenient for the user and more economical in the printing of the map if the two constituent parts of the Soil Survey of Great Britain had collaborated to produce two complete sheets of this border country instead of each separately producing two incomplete sheets. The memoir caters for the needs not only of the soil specialist, but also of the land user, the country planner, and students of ancillary sciences such as geology and ecology. The work of combining these many points of view has been well executed, and has produced a very readable account of the physical environment of the district. The main soil associations and series are adequately and concisely described and their relationships to local types of agriculture are indicated. Data of mechanical and chemical composition are given in an appendix. The soil maps are excellent, and many beautiful photographs, not all of which are illustrative of the soils, are included. In some respects the memoir has been produced with unnecessary extravagance, which is reflected in the price.

International Conference in Munich of University Teachers

THE ninth conference of university teachers, organized by the International Association of University Professors and Lecturers, will be held in Munich during September 3–8, under the chairmanship of Prof. Francesco Vito. The aim of the conference is to discuss problems fundamental to universities throughout the world. In particular, the following topics will be considered: the scientific and social responsibilities of the university teacher in relation to his academic independence, and the effect of these responsibilities and of the pressure of non-teaching and outside work on a proper fulfilment of his task; the maintenance of a university tradition and the training of future university teachers; the conditions of employment and the contractual obligations of university teachers working in countries other than their own; scientific research in the universities and its relations with industrial research; the status and careers of research workers and those engaged in the social sciences; the place of classical studies and the humanities in a general education. The conference is open to all university teachers, whether members or not of the Association. Further information can be obtained from the Secretary, International Association of University Professors and Lecturers, 21 Dawson Place, London, W.2.

Oversea Service Division, Colonial Office

THE following appointments have recently been made in the Oversea Service Division, Colonial Office: C. Yates (inspector of works, Public Works Department, Nigeria), chief supervisor of forest works, Forestry Department, Sierra Leone; W. A. Dos Santos (pathologist, Trinidad), pathologist, Federation of Nigeria; D. J. Bargman (meteorologist, East African Meteorological Department, East Africa High Commission), regional representative (Uganda), East African Meteorological Department, East Africa High Commission; C. J. Cartledge (meteorological assistant, Nyasaland), meteorological assistant, East African Meteorological Department, East Africa High Commission; J. P. Henderson (assistant director, East African Meteorological Department, East Africa High Commission), deputy director, East African Meteorological Department, East Africa High Commission; D. McCullum (meteorologist, East African Meteorological Department, East Africa High Commission), regional representative (Tanganyika), East African Meteorological Department, East Africa High Commission; B. W. Thompson (meteorologist, East African Meteorological Department, East Africa High Commission), regional representative (Kenya), East African Meteorological Department, East Africa High Commission; Dr. I. E. M. Watts (assistant director of Malayan meteorological services, Singapore), director of the Royal Observatory, Hong Kong; D. O. Mill (senior statistician, Jamaica), deputy director of statistics, Jamaica; Dr. D. H. L. Rollinson (chief veterinary research officer, Uganda), assistant director of veterinary services (research), Uganda; T. G. C. Vaughan-Jones (director of game and tsetse control, Northern Rhodesia), commissioner for rural development, Northern Rhodesia; D. I. Allen, agricultural engineer, British Guiana; R. M. Veevers-Carter, assistant fisheries officer, Aden; R. W. Bartholomew, geologist, Fiji; E. B. Wolfenden, geologist, Sarawak; M. J. Glover, scientific officer (West African Stored Products Research Unit), Federation of Nigeria; L. E. Stephen, senior scientific officer, West African Institute for Trypanosomiasis Research, Nigeria; P. F. Byrne, veterinary officer, British Guiana; H. Steding-Jessen, veterinary officer, Gold Coast; K. S. Thomson, veterinary officer, Tanganyika.

Announcements

DR. D. G. O. MORRIS, senior lecturer at the University College of North Wales, Bangor, has been appointed to the University of London readership in electrical engineering tenable at the Imperial College of Science and Technology.

THE culture collection of bacterial plant pathogens built up by Dr. W. J. Dowson (who retired in 1952 from the staff of the Botany School, Cambridge) has now been transferred to the Plant Pathology Laboratory of the Ministry of Agriculture, Fisheries and Food, 28 Milton Road, Harpenden, Herts, where it will be in the care of Mr. R. A. Lelliott. Dr. Dowson is continuing his researches on various aspects of plant bacteriology at the Botany School, Cambridge.

Two fellowships have recently been awarded by the Mental Health Research Fund, the first of which, a Leverhulme fellowship of a total value of £3,600, tenable at the Department of Anatomy, University College, London, is to Dr. Brian G. Cragg, to continue his research on the function of the hippocampus. The other award is a Mental Health Research Fund fellowship, of £900 a year for two years, to S. Folkard, who is working at the Netherne Hospital, Coulsdon, Surrey, on an assessment of the contribution which social science techniques can make to the diagnosis and treatment of patients in a mental hospital. The Mental Health Research Fund will be offering further fellowships for competition during the coming year.

ERRATUM. In the article entitled "Growth and Sexual Maturity in Aquatic Mammals", by Dr. R. M. Laws, in *Nature* of July 28, p. 193, the lengths quoted in Table 1 should be "in feet" for the Cetacea and "in inches" for the Pinnipedia.

ROYAL GREENWICH OBSERVATORY

ANNUAL REPORT FOR 1955–56

THE annual report of the Astronomer Royal for the period April 1, 1955–March 31, 1956*, deals with the Royal Greenwich Observatory under three headings: Greenwich and Abinger; Herstmonceux; and Hartland.

As no major overhaul of the Yapp 36-in. reflector had taken place since its erection, it was decided to dismount it earlier than the progress of its dome at Herstmonceux would otherwise have justified, and to use the poor observing months in reconditioning it, repainting the structure and re-wiring where necessary. The repainting was largely completed by the end of the year under report, but the re-wiring remains to be done. Defects of the figure in the main mirror were referred to in the 1954–55 report, and it was decided to dispatch the mirror to the firm of Sir Howard Grubb, Parsons and Co., Ltd., for the removal of these defects.

Observations of the four bright minor planets for position have been continued with the astrographic refractor, and reductions of the plates are well advanced. Investigations on the systematic errors of deduced place due to photographing well away from the meridian were carried out by exposures in three-star fields at widely different declinations, and most of the thirty-nine hour-angle plates taken during the year have been measured and reduced. The magnitude and sign of the effect vary with the declination of the test field in such a way that the small displacements found cannot easily be attributed to such effect as flexure. It is impossible to interpolate to other declinations so long as a physical explanation is lacking, but it is not considered likely that the effect can appreciably influence astrometric work except in the few cases where large ranges in hour-angle are deliberately employed, for example, in single-station parallax work on minor planets. Some test plates taken by Dr. D. W. Dewhirst with the new 17/24-in. Schmidt camera of the Cambridge Observatories have been examined to find whether the optically similar instrument planned for Herstmonceux will be suitable for astrometry.

In accordance with the recommendations of the International Union of Pure and Applied Physics, recording of the general ionizing flux under 10 cm. of lead has been done without any significant interruption, and the diurnal and other variations have been investigated. The cosmic-ray flare of February 23 last was recorded, showing more than 100 per cent increase; observatories throughout the world are supplying information on this remarkable flare (see *Nature*, July 21, p. 125).

Routine observations with the Lyot birefringent $H\alpha$ filter on the 6½-in. Newbegin refractor started on June 13, 1955, and on 175 days out of the 293 days up to March 31 daily photographs were taken of the Sun's disk and of the prominences visible at the Sun's limb. Also, special series of photographs were taken on about twenty-five occasions during periods of flare-activity on the Sun. The photographs were taken on red-sensitive 35-mm. film specially provided by Kodak, Ltd.; the film, which is of fine grain, requires an exposure of about ½ sec. under favourable sky conditions. The image-size is approximately 21 mm. to the solar diameter, and the photographs normally reveal details down to a size of 5″ of arc. The firm of Kodak, Ltd., has taken considerable trouble to produce a suitable film, and various difficulties experienced with the film have been overcome.

Among the numerous matters dealt with in the report is a short account of the Electronics Laboratory in which experimental work on operating a quartz-crystal oscillator with the resonator at the temperature of liquid hydrogen has been carried out at Oxford with the help of the Clarendon Laboratory. The experience derived has suggested modifications in both the low-temperature and the electronic-measuring equipment, and results obtained are so promising that it is intended to continue these experiments. Acting on the request of Study Group 7 of the International Radio Consultative Committee to investigate the possibility of high-accuracy frequency comparison by means of the 16- and 60-kc./s. controlled transmissions from Rugby, experimental equipment for continuous recording of the phase of these transmissions has been built, and an accuracy of a few parts in 10^{10} has been achieved. This method of frequency-checking possesses such accuracy and simplicity that it has been chosen for the next series of tests at Oxford.

At Abinger the routine work has continued, and it is intended that this Station will continue to provide data throughout the International Geophysical Year. The building of the new magnetic observatory at Hartland was commenced in the early summer of 1955, and it is expected that it will be operating by the late summer of this year.

The routine calculations and proof-reading in the preparation and printing of the publications for which the Nautical Almanac Office is responsible have been continued as usual. It has been agreed that the "Abridged Nautical Almanac" and the "American Ephemeris and Nautical Almanac" shall become identical, beginning with the 1958 editions. The unification of the two publications has required a number of changes in both, but as complete agreement has been reached on the numerous details of presentation, most of the copy is now ready for photographic reproduction. Among the ramifications of the work of the Nautical Almanac Office may be mentioned the prediction of occultations of radio sources by the Moon. The predictions are at present restricted to the twenty-six radio sources of the second Cambridge survey with a flux density not less than 50 units within the zodiacal band, the unit being 10^{-26} W. m.$^{-2}$ (c./s.)$^{-1}$. The predictions are sent in manuscript form direct to the radio stations: those for July–December 1955 were sent to eight stations, and those for January–July 1956 to fourteen stations.

* Report of the Astronomer Royal to the Board of Visitors of the Royal Greenwich Observatory. Pp. 25. (Herstmonceux: Royal Greenwich Observatory, 1956.)

It has been decided that the duplex design for the Isaac Newton telescope be abandoned and that attention be concentrated on the construction of a conventional paraboloid telescope. A committee is working out a detailed design on this basis, and substantial progress is reported.

ONTARIO RESEARCH FOUNDATION

REPORT FOR 1955

THE annual report of the Director of Research of the Ontario Research Foundation for 1955* refers to additions to the duties and responsibilities of the Foundation in consequence of the termination of the Research Council of Ontario. The Foundation is now authorized to spend 50,000 dollars a year on scholarships and fellowships for postgraduate students in science, and for the year 1955–56 forty-one scholarships were awarded. The estimates also provide for grants of 145,000 dollars to universities and colleges in Ontario for postgraduate research in the natural sciences and engineering, and sixty-four such grants were made for 1955–56. The advisory committees for research in fisheries and wild-life and in forestry and forest products and for industrial research have been reconstituted, and their membership is given in an appendix. The Director again notes the growing difficulty in recruiting an adequate number of Canadian graduates with the requisite scientific background and character and also the need for further space and equipment, particularly for pilot-plant operatives in the Metallurgy and Chemistry Departments in view of the growth of the Foundation's activities over the past ten years, during which its income has increased from 364,385 dollars in 1945 to 1,014,086 dollars in 1955.

The Biochemistry Department has achieved further success in modifying chemically a lignin sulphonic acid phenol condensate and applying it in tanning heavy leather, and it is hoped that the Department will be able to re-examine potential sources of vegetable tannins in Canada. Workers under the Rice Mills Fellowship have met with continued success in the production of humidifier plates from rice hull ash, and they are now engaged in a study of experimental lots of acoustic tile. Besides co-operative work with other Departments, the infra-red laboratory has been used by eight companies in their own investigations. A close correlation has been noted in the oils and fats laboratory between the tendency of an oil to deteriorate and its ability to react with 2-thiobarbituric acid, and fodder yeast has been produced from cheese whey by a simple process.

The Department of Chemistry, using improved methods of paper chromatography, has determined quantitatively the nine lower members of the phosphoric acid series and occasionally up to the twelfth member, and has continued its work on phosphate glasses. It is proposed to concentrate the work of the air pollution laboratory on careful analysis of the atmosphere in relation to climatic conditions, and on a determination of the organic constituents and the ozone concentration. A commercial model has been constructed which is able to check accurately sixty piezo-electric quartz crystal units per hour.

A study of the viscosities of grafted copolymer solutions showed that the viscosity increases rapidly as the shear-rate decreases for branched copolymers but is unaffected for linear copolymers. The electroplating laboratory has found that large inclusions in commercial steel could be an important source of failure for nickel deposits of the order of 0·0001 in. thickness from a low-*p*H Watts bath. Work on the utilization of waste sulphite liquor continued.

The volume of work in the Engineering Section of the Department of Engineering and Metallurgy is two and a half times that in 1954. Pilot-plant work in the research on controlled-density steel has yielded important results on the economics of the process, furnace design and the production of the reducing gas; work in the ferrous metallurgy laboratory included the chemical production of pure magnetite, the decrepitation of ores at various temperatures to improve concentrates, the design and construction of improved magnetic separators, particularly for handling extremely fine particles, and the design and construction of a machine for pelletizing iron ore concentrates. Fundamental work in the physics of metals is aimed at acquiring new knowledge about the fatigue process and applying this knowledge to discover new materials of high fatigue strength, as well as developing tests to measure fatigue damage. In the X-ray laboratory a helium bath has been obtained and the range of the X-ray spectrographic analysis has been extended to elements of lower atomic numbers.

In the Department of Parasitology, work continued on the blood protozoa in birds; and tests on the antimalarial drugs 'Daraprim', 'Camoquin' and 'Aralen' against *L. simondi* in ducks showed that 'Daraprim' prevented parasitæmia, but neither of the others had any prophylactic or therapeutic value. The investigation of the life-history of two species of flukes that occur in foxes and other carnivores was completed; 30 per cent of almost a thousand nests of forty-five species of birds examined were infested with thirteen different species of *Protocalliphora*. In the Department of Physiography laboratory work was completed on minerals in the colloidal fraction of glacial tills and water-laid clays in southern Ontario, and a study was made of climate for peaches in Ontario. The Textile Department is concentrating its resources on short-term work in the immediate future, and undertaking only one or two fundamental problems, including the physical properties of viscose yarn and the resistance of nylon to immersion in water and exposure to light.

* Ontario Research Foundation. Annual Report, 1955. Pp. 35. (Toronto: Ontario Research Foundation, 1956.)

RESEARCH ON ANIMAL PRODUCTION

THE British Society of Animal Production was established towards the end of the Second World War for the purpose of bringing together those interested in both the science and practice of the breeding, feeding and management of farm animals, and the recently published volume of its Proceedings for 1955* contains many interesting and important papers on current research in animal production. The following examples indicate the wide range of

* Proceedings of the British Society of Animal Production, 1955. Pp. 122. Edited by I. L. Mason and G. Wiener. (Edinburgh and London: Oliver and Boyd, Ltd., 1956.) 15s.

the problems under investigation by many different workers throughout Great Britain.

Work at the University College of North Wales, Bangor, shows that the weight of the lamb in hill sheep in September is probably the best single guide to adaptation and production, for this shows the best correlation with adult weight and has a heritability of $0{\cdot}68 \pm 0{\cdot}06$. From the rumen contents of hill sheep in Scotland the selective grazing on heaths and heathers in different months has been assessed. In fast-growing suckling lambs implantation of œstrogen caused but little increase in live weight, but reduced carcass fat and caused some cases of vaginal prolapse. By comparing worm-free lambs with those artificially infected, the depression of live weight and wool growth was measured and a method of grazing management to prevent infection is described. Under similar management, for each additional pound at birth a difference of 2–4 lb. may be expected in lambs at weaning.

A pasture-sampling method for the estimation of daily dry-matter intake of grazing animals is described, and this was used for measuring the intake of cows in different circumstances. The management necessary to prevent pregnancy toxæmia in sheep is described. In field trials flock fertility was increased by treatment of the ewes with pregnant-mare serum hormone. The time onset of bloat in cattle and its severity are affected by pasture conditions, rate of grazing and previous feeding. Free-range grazing of pigs allows them to select young leafy leguminous growth, while close folding restricts selection, so that in summer free-range grazing effects a saving of 32 per cent of a medium protein meal whereas close-folding saved only 8 per cent.

From an analysis made of the progeny tests of bulls in different herds, it is concluded that within a breed only a small fraction of the difference between herds in milk yield is genetic, but that for fat percentage the fraction is rather higher. In medium- and high-producing herds the first lactation record is superior to the second as an indication of the cow's inherent capacity for yield. By applying magnesium sulphate to grass intended for silage, the magnesium content of the blood of the cattle consuming it was raised, but dropped again when they were turned out to young grass, showing that no body reserves of magnesium are built up.

If the present standard of this publication is maintained, it will prove to be an important contribution to the literature on animal production by presenting in a concise manner an up-to-date account of research work in progress.

MULTIPLE FIRING AT CENTRAL SYNAPSES

By Prof. A. K. McINTYRE, R. F. MARK and J. STEINER
Department of Physiology, University of Otago, Dunedin

ELECTROPHYSIOLOGICAL investigations in which penetrating microelectrodes have been used for recording action in the central nervous system have led to a number of reports of single neurones discharging repetitively in response to brief peripheral stimulation[1–5]. In most of these and other similar reports little attention has been paid to this synaptic peculiarity, despite the fact that little or no such repetitive postsynaptic firing occurs in the most intensively studied central synaptic system, the spinal stretch-reflex arc[6,7]. Exceptions are the papers of Bishop, Jeremy and McLeod[8] and of Rose and Mountcastle[9], in which the phenomenon of multiple firing was singled out for study, in the lateral geniculate and thalamic afferent relay systems respectively.

In our own microelectrode studies during the past three years, neurones firing repetitively in response to single-shock presynaptic stimulation have been frequently encountered. These stand in striking contrast with motoneurones, which scarcely if ever discharge more than once to similar stimulation of the monosynaptically-connected afferent fibres of the stretch-reflex arc. The contrast is illustrated in Fig. 1, which displays responses of single units in various parts of the nervous system, each recorded by way of a Ling–Gerard type glass micropipette[10]. The typically single monosynaptic discharge of a motoneurone is shown in *A*; multiple responses of other neurones are illustrated by records *B–F*, the details of which are explained in the legend. Examples such as these suggest that the behaviour of motoneurones, upon which so much of our present knowledge of synaptic mechanisms is based, so far from typifying synaptic action generally, actually represents an exceptional case.

The synaptic system which in our hands has proved most favourable for experimental analysis of the multiple firing phenomenon is the relay from lumbosacral primary afferent fibres to second-order neurones the axons of which course headwards in the dorsolateral tract. In earlier studies of the whole tract response, prolonged, irregular firing after the initial nearly synchronous tract discharge was noted[11,12], but it was not certain until unit responses were obtained, such as those of Fig. 1 *B*, whether individual tract fibres actually fired more than once. Our experiments have now revealed that many of the fibres do behave in this fashion, and the form of the whole tract after-discharge is adequately explained by summation of the responses of many repetitively-firing fibres.

The experimental advantages of the dorso-lateral tract synaptic relay can be summarized as follows. The tract fibres are large, and, lying superficially during most of their course in the spinal cord, are well suited both for recording and direct stimulation. Thus their responses to presynaptic action can be studied with the recording electrode remote from the actual synaptic region, which we have found to be extremely vulnerable to injury even by the finest electrodes. Furthermore, antidromic volleys can be readily set up in the tract fibres, a matter of considerable technical difficulty in many of the other central synaptic systems of like behaviour. Because of these favourable features, it has been possible to obtain new evidence bearing on the mechanisms responsible for repetitive firing. Our results will now be considered in relation

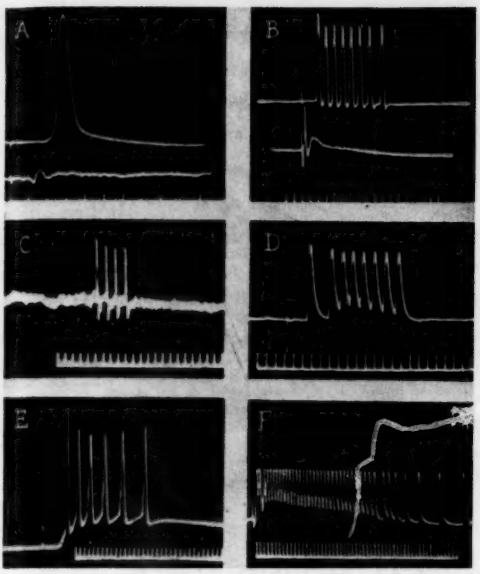

Fig 1. Discharges recorded from units in different parts of the central nervous system by means of Ling–Gerard micropipettes. The top record in *A* is the monosynaptic discharge, recorded intracellularly, of a hamstring motoneurone in response to a volley in the combined biceps and semitendinosus nerves. The upper trace in *B* is the response of a single dorso-lateral tract fibre to a stimulus applied to the ipsilateral seventh lumbar dorsal root. The lower beams in each case display the afferent volley at its entry into the spinal cord. *C* shows the response of a cell in the cuneate nucleus to a single volley in the superficial radial nerve. *D* that of a spinal cord internuncial to single-shock stimulation of a lumbar dorsal root. *E* illustrates the firing of a neurone in the cerebral cortex (somatic sensory area) elicited by a single stimulus to the medial lemniscus in the medulla. *F* shows the discharge of a Renshaw cell in the ventral horn of the seventh lumbar segment in response to a single volley in the corresponding ventral root. All records from cats under barbiturate anæsthesia. Time marks show millisecond intervals

to various possible explanations which might be advanced to account for the phenomenon.

Injury discharge. In most of the earlier reports, the potentials were recorded from postsynaptic cell bodies, and it is possible that slight electrode damage to a cell, normally responding singly, might create a tendency to repetitive discharge, a common effect of injury. Records such as the one shown in Fig. 1 *B* effectively dispose of the notion that electrode damage to cell bodies is a necessary requirement for such synaptic behaviour, since the discharge was recorded from a tract fibre, the actual synaptic region being quite undisturbed. The possibility of the fibre itself being in a similar abnormal state through electrode damage is precluded by the observation that direct tract stimulation gives but a single (antidromic) response.

Temporal dispersion of primary afferent volley. Simple temporal dispersion of impulses ascending primary afferent fibres in the dorsal funiculus undoubtedly occurs, especially in fibres of small and intermediate size-range. Since convergence of such fibres (especially from skin receptors) on to dorso-lateral tract units has been demonstrated[13], such dispersion could lead to the impingement upon individual second-order neurones of a prolonged shower of presynaptic impulses. Were this the sole explanation, latency of the first discharge would be expected to remain relatively independent of volley size, being largely determined by conduction time in the largest, lowest-threshold afferent fibres making synaptic contact. This, however, is not the case, latency being much longer with small than with large presynaptic volleys. Furthermore, reduction of temporal dispersion by stimulating the afferent fibres in the dorsal column near the site of synaptic relay does not substantially reduce the repetitive firing. Though such dispersion may contribute to the after-discharge mechanism, we do not think it can account fully for the phenomenon.

Repetitive action of presynaptic fibres. The 'dorsal column relay' of Hursh[14] could prolong presynaptic action by causing repetitive firing of individual primary afferent fibres. However, the phenomenon is sensitive to temperature, and since we have not detected any clear-cut change in tract discharge patterns at different cord temperatures, it does not seem likely to be an important factor.

Internuncial activity. The most popular hypothesis at the present time postulates the operation of internuncial delay-paths[15] to account for the prolongation of action. In one specific form of this hypothesis, collaterals from the principal postsynaptic neurones constitute the first link in the recurrent chain[8]. Our observations have definitely excluded this particular scheme, at least for the dorso-lateral tract relay, for should it be operative, antidromic conduction of impulses by tract fibres would also lead to their firing repetitively, and this, as stated already, does not occur. It is difficult to obtain unequivocal evidence of the possible role of purely presynaptic delay-circuits. Nevertheless, it may be doubted whether internuncial activity could bring about discharges of such striking regularity and rapidity. In the case of the classical flexor reflex, in which internuncial chain activity certainly figures prominently, the successive bursts of polysynaptic bombardment impinge on flexor motoneurones with less regularity and at a slower rate[16] than, for example, the discharge shown in Fig. 1 *B*. Furthermore, in preliminary experiments it has not been found possible to abolish the repetitive firing with the powerful internuncial depressant, myanesin. The repetitive discharge of Renshaw interneurones[3,5] may be cited as a further indication that prolonged postsynaptic activity may occur in the absence of repetitive presynaptic action. There is no evidence that internuncial chains are involved in the activation of these cells by recurrent axon collaterals, yet a synchronous ventral root volley coursing antidromically for a few centimetres at most can bring about remarkably rapid and prolonged firing (Fig. 1 *F*).

At present, therefore, we incline to the view that explanations based on repeated bombardment of second-order neurones by presynaptic impulses cannot account fully for the phenomenon of multiple firing. Prolonged transmitter action exerted by individual impulses in the presynaptic terminal ramification appears to us a more likely hypothesis.

Whatever the exact presynaptic mechanism may be, the ability of the postsynaptic cells to fire so rapidly in response to sustained excitation calls for comment, in view of the failure of motoneurones to discharge repetitively at a fast rate even with repeated presynaptic excitation. Powerful depolarizing pulses applied directly to the motoneurone membrane can evoke several impulses in rapid succession[17], but excitability soon fails, and sustained firing at rates such as those seen in Fig. 1, *B–F*, does not occur. One suggestion which can be advanced to account for this difference is that neurones capable of sustained rapid firing are so organized that impulses do not

invade regions of slow recovery such as the dendrites[18]. According to this view, the transmitter agent brings about in postsynaptic dendrites a long-lasting depolarization which acts as a generator potential evoking repeated discharges in the cell body and axon, much as described by Kuffler and Eyzaguirre in crustacean stretch receptor neurones[19].

As to the significance of the multiple firing phenomenon, its prominence in afferent nuclear relays suggests that it might play an important part in the neural processes underlying sensation. It is conceivable that temporal expansion of afferent signals could act as a matching device between receptors and higher centres. However, the extensive convergence of primary afferent fibres on second-order neurones suggests other possibilities. Since recruitment of additional converging afferent fibres to the presynaptic volley commonly leads, not to occlusion, but to an increase in the number of postsynaptic impulses discharged, the multiple firing mechanism provides a means of converting a spatial pattern in primary afferent fibres into temporal patterns of impulses in individual second-order neurones.

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[1] Marshall, W. H., *J. Neurophysiol.*, **4**, 25 (1941).
[2] Lloyd, D. P. C., *J. Neurophysiol.*, **5**, 435 (1942).
[3] Renshaw, B., *J. Neurophysiol.*, **9**, 191 (1946).
[4] Amassian, V. E., *J. E.E.G. Clin. Neurophysiol.*, **5** 415 (1953).
[5] Eccles, J. C., Fatt, P., and Koketsu, K. J., *J. Physiol.*, **126**, 524 (1954).
[6] Renshaw, B., *J. Neurophysiol.*, **3**, 373 (1940).
[7] Lloyd, D. P. C., *J. Neurophysiol.*, **6**, 293 (1943).
[8] Bishop, P. O., Jeremy, D., and McLeod, J. G., *J. Neurophysiol.*, 16 437 (1953).
[9] Rose, J. E., and Mountcastle, V. B., *Bull. Johns Hopkins Hosp.*, **94**, 238 (1954).
[10] Ling, G., and Gerard, R. W., *J. Cell. Comp. Physiol.*, **34**, 383 (1949).
[11] Grundfest, H., and Campbell, B., *J. Neurophysiol.*, **5**, 275 (1942).
[12] Lloyd, D. P. C., and McIntyre, A. K., *J. Neurophysiol.*, **13**, 39 (1950).
[13] McIntyre, A. K., and Mark, R. F. (in preparation).
[14] Hursh, J. B., *J. Neurophysiol.*, **3**, 166 (1940).
[15] Lorente, de Nó, R., *J. Neurophysiol.*, **1**, 207 (1938).
[16] McIntyre, A. K. (unpublished observations).
[17] Brock, L. G., and McIntyre, A. K., *Proc. Univ. Otago Med. Sch.*, 31 19 (1953).
[18] Lloyd, D. P. C., *J. Gen. Physiol.*, **35**, 255 (1951).
[19] Kuffler, S. W., and Eyzaguirre, C., *Fed. Proc.*, **14**, 89 (1955).

WATER ECONOMY OF TROPICAL MERINO SHEEP

By Prof. W. V. MACFARLANE, R. J. MORRIS and B. HOWARD
Department of Physiology, University of Queensland

NEARLY eight million sheep live on unshaded plains in tropical Australia. Since May 1954, we have studied the thermal adaptation of merinos at Julia Creek, Queensland, 21° S. lat. and 142° E. long. Summer ambient temperatures reach 46° C. (115° F.), and for six months the mean monthly maximum temperature is above 35° C. (95° F.). For the three winter months, temperatures range from 0° to 25° C.

The water intake, output and distribution of sixty young merinos have been followed through two winters and two summers. The sheep have proved physiologically hardy and well adjusted to extremes of heat, water supply and nutrition. They normally lived on the native pasture; but they were trained to feed on native grass hay and maize in yards. In the yards mean winter water intake over 120 sheep-days was 7·3 ml./kgm./24 hr.; and in midsummer it reached a mean of 88·8 ml./kgm./24 hr. Corresponding 2 p.m. respiratory-rates were 38 ± 11/min. in winter and 154 ± 43/min. in summer. Urine output (8 sheep) in winter was 1·34 ± 0·65 l./24 hr. and in summer 0·73 ± 0·39 l./24 hr. The mean output, in ml./kgm./24 hr., was 35 and 46 in successive winters, and 24 and 15 in successive summers. We have found that a standard heat stimulus of 40° C. releases antidiuretic substances in summer, but not in winter. Water for evaporative cooling by panting is provided in summer by drinking twelve times the winter water intake; and by reduction of urine to half the winter volume. Young sheep, also, stored 28 per cent more extracellular water in summer than in winter.

Sheep standing in the open, between noon and 2 p.m. in summer, were exposed to air temperatures between 36° and 42° C., and radiant insolation of 700 k.cal./m.²/hr. Wool tip temperatures rose to 87° C. (190° F.) and the corresponding skin temperature was 42° C., with rectal temperatures of 40·0–40·5° C. Tip wool heats rapidly in the sun and is cooled by air movement. When the terminal 1 cm. was clipped away reflectance doubled (to 0·36 cal./cm.²/min.) and the clean tip temperature fell by 17–20 deg. C. The dark weathered tip accepts more heat than freshly cut wool; but the skin is insulated effectively, for 4 cm. of wool sustained a gradient of 45° C. between tip and skin. An inverse relation was observed between length of wool and respiratory-rate of sheep in the sun. Two pairs of similar merino wethers, for example, were compared while insolated. Two shorn sheep with 1 cm. of wool had skin temperatures 3 deg. C. hotter than the unshorn carrying 3·5 cm. of wool. Shorn sheep panted at 230 ± 26/min., while unshorn sheep panted at 108 ± 23/min. in an ambient air temperature of 38° C.

The interactions of these heat loads and water reserves were studied by depriving five wethers of water for four days, and three for five days. The 50 kgm. animals were 27 months old. They stood in the summer sun and were allowed full rations of *Astrebla* (Mitchell grass) hay supplemented with grain.

Table 1

	Initial	120 hr. without water	Per cent change
Body weight (kgm.)	50·3	38·5	− 23
SCN space (l.)	13·3	7·3	− 45
Plasma vol. (l.)	3·16	1·74	− 45
Plasma sodium (m.eq./l.)	144·1	157·0	+ 9
Plasma chloride (m.eq./l.)	111·0	142·0	+ 28
Plasma osmotic pressure (Δ° C.)	0·585	0·782	+ 34
Max. urine osmotic pressure (Δ° C.)	4·180	5·940	+ 42

Mean values for body fluid volumes and concentrations induced in three merino wethers by five days without drinking water. Food was supplied. The sheep were exposed to sun in air temperatures reaching 40° C. (104° F.) with relative humidity between 10 and 50 per cent

Rectal temperature reached 41° C., extracellular fluids (Table 1) were reduced by 45 per cent and the plasma osmotic pressure increased by 34 per cent. Plasma protein concentration rose 60 per cent and the hæmatocrit 39 per cent. Plasma sodium rose only 9 per cent, though urinary sodium/potassium fell, so sodium probably entered cells. Each plasma constituent seemed separately adjusted to dehydration.

Urinary water-loss averaged 1,680 ml. in 120 hr. (0·23 ml./min.) and in that time 702 m.equiv. sodium and 486 m.equiv. potassium were excreted. Urine volume fell from 585 ml. to 130 ml./24 hr. by the fifth day. Two sheep had less power of renal concentration after the third day, although urine volume continued to fall. Osmotic pressure of the urine rose to a maximum of 3,196 m.osmols and specific gravity reached 1·069. Less than half the osmolarity of the urine could be accounted for by sodium and potassium salts. As dehydration continued the urine sodium/potassium ratio fell from 1·8 to 1·2. When offered water after five days the sheep drank 7–9 l. at once. The following 24-hr. urine volume did not exceed 250 ml., but the sodium/potassium ratio fell to 0·2. Sodium was thus retained to hold the water ingested. The sheep were apparently unharmed by five days without water. The Schmidt-Nielsens[1] found that kangaroo rats concentrate urine to 5·5 osmols. The rock wallaby *Setonyx*[2] achieves 2·1 osmols. Merinos approach the camel in power of water conservation[3].

In contrast with the day to night change of rectal temperature over 4–7 deg. C. found in the camel, the merino in summer has a fluctuation of only 1·5–2·0 deg. C. The relative stability is achieved by panting. Sheep, accordingly, lose water somewhat faster than the camel. But the merino tolerates a similar water loss to the camel, and survives more extracellular volume reduction than is possible for man. From a mean weight-loss of 11·8 kgm. it was found in the dehydrated merino that 5·2 kgm. could be assigned to tissue wastage and intracellular water loss. These losses approach those survived by camels. Attempts to measure directly intracellular water of merinos by antipyrine failed because of the rapid rate of removal of antipyrine in sheep and the unpredictable occurrence of impossible dilution curves.

Adaptation to high heat loads and dehydration by merinos involves insulation by wool against radiation, production of antidiuretic substances in summer to help concentrate urine to 3 osmols, toleration of reduction of plasma volume to half, and increase of plasma osmotic pressure to 440 m.osmols/l.

We are grateful to the Commonwealth Scientific and Industrial Research Organization Wool Fund for a grant. Mr. G. R. Moule, Mr. R. B. Young and their associates at Toorak gave invaluable help in the field.

[1] Schmidt-Nielsen, K., and Schmidt-Nielsen, B., *Physiol. Rev.*, **32**, 135 (1952).
[2] Bentley, P. J., *J. Physiol.*, **127**, 1 (1955).
[3] Schmidt-Nielsen, K., *Unesco Courier*, No. 8, 29 (1955).

EFFECT OF TEMPERATURE UPON THE CROSS-LINKING OF POLYETHYLENE BY HIGH-ENERGY RADIATION

By R. M. BLACK

British Insulated Callender's Cables, Ltd., Research Organization, 38 Wood Lane, London, W.12

RECENT work upon the degradation of polymethyl methacrylate by gamma-radiation[1] has shown that the radiation appears to have a greater effect at a higher temperature and that less energy is therefore required to degrade the polymer at 74° than at 18° C. With poly*iso*butylene, the effect has been studied in greater detail[2] and the experiments carried out leave no doubt as to its validity. From the initial experiments the dependence on temperature would seem to be rather unusual in character; the number of main-chain fractures for a given energy deposition increases approximately proportionally to the absolute temperature.

In view of the possible implications of this phenomenon for the mechanism by which radiation-induced changes are brought about in polymers, the behaviour of a system which exhibits cross-linking rather than degradation has been investigated. Polyethylene is particularly suitable for this purpose as, not only has its behaviour under irradiation been studied in considerable detail by Charlesby and his colleagues[3], but also the irradiated polymer exhibits rubber-like elasticity at temperatures above 120° C. which can readily be measured and is directly related to the degree of cross-linking[4].

A series of polyethylene specimens ('Alkathene' grade 7), cut to the shape of standard 3-in. dumb-bells, were irradiated in a 400-curie cobalt source over a temperature range − 196° to 75° C. The energy deposited in the specimen was estimated by ferrous sulphate dosimetry, taking the value of $G(Fe^{3+}) = 20$.

Elastic moduli of the irradiated specimens were measured by suspending the specimen in a constant temperature oven at 140° C. and applying weights at regular intervals by means of a cantilever device through the roof of the oven.

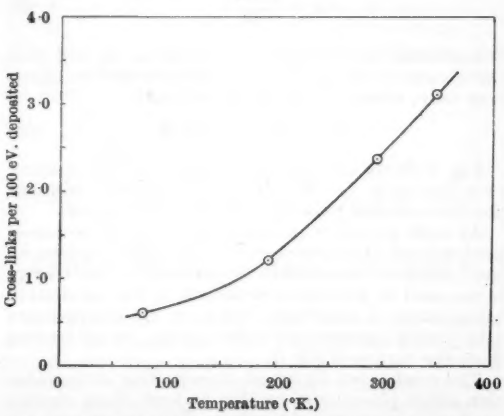

Fig. 1. Effect of temperature upon the cross-linking of polyethylene by gamma radiation

For rubber-like elasticity, the elastic modulus is inversely proportional to the molecular weight between cross-links (M_c), and can be expressed by the relationship :

$$E = \frac{3\rho R_g T}{M_c} \quad (1)$$

where E is the elastic modulus in dynes/cm.^{2}, ρ the density of the polymer ($\sim 0{\cdot}92$), R_g is the gas constant ($8{\cdot}3156 \times 10^7$ in c.g.s. units), and T the absolute temperature at which the measurement is made (413° K). Now, M_c is defined by the expression :

$$M_c = \frac{M_0}{\gamma} \quad (2)$$

where M_0 is the initial number-average molecular weight of the polymer and γ the cross-linking index or average number of cross-links per molecule produced by unit radiation dose. If q is the fraction of monomers cross-linked by such a dose and the number of cross-links is proportional to the radiation dose, R, received, then in a polymer of initial molecular weight M_0 there will be $M_0/14$ carbon atoms capable of being cross-linked and the molecular weight between cross-links after a radiation dose R will be given by :

$$M_c = \frac{14}{qR} \quad (3)$$

Substituting this value for M_c in equation (1) gives :

$$E = \frac{3\rho R_g T q R}{14} \quad (4)$$

It is desirable to express the amount of cross-linking produced by a given radiation dose in terms of the number of cross-links produced by an energy deposition of 100 eV., in agreement with present-day radiation chemistry procedure (G values), whence the G value for cross-linking (G_c) will be given by :

$$G_c = \frac{\text{fraction of carbons cross-linked in 1 gm. polymer}}{\text{energy deposited in 1 gm.}} \times 100$$

$$G_c = \frac{(N/14)q.R \times 100}{R} \quad (N \text{ is Avogadro's number, } 6{\cdot}023 \times 10^{23})$$

If R is initially expressed in eV. per gm. this becomes :

$$G_c = \frac{100Nq}{14} \quad (5)$$

Substituting this value of q in equation (4) will give the G value in terms of elastic modulus and radiation dose only, whence it can be shown that

$$G_c = 6{\cdot}35 \times 10^{14} E/R \quad (6)$$

Fig. 1 shows the values calculated in this manner over the range 77°–348° K. It is uncertain whether the curve should pass through the absolute zero.

As with polymers in which degradation processes predominate after exposure to high-energy radiation, the measured values leave no doubt that less energy is required to produce a cross-link as the irradiation temperature is increased. Moreover, the temperature relationship appears to be very similar, as can be seen from the curves of Fig. 2.

The mechanism by which cross-linking or degradation takes place must involve at least three stages : excitation or energy absorption, dissociation with ion or radical formation, and interaction of the excited radicals or ions to give stable products, whether carbon–carbon double bonds, cross-links or by disproportionation chain fracture. The amount of energy initially absorbed by the molecules which results in chemical change is very small, as bond-energies in general are of the order of 3–4 eV. and a larger proportion of the energy is either degraded into heat or re-emitted in the form of fluorescence radiation, which may afterwards be re-absorbed to bring about photo-dissociation[5]. This absorption process is generally held to be independent of temperature and it can therefore be concluded that the temperature effect is to be found in either the dissociation or interaction stages of the process. At first sight it might appear that the interaction stage is the critical one, as a plot of log G_c against $1/T$ is approximately linear down to − 80° C. ; but, in view of the similar dependence on temperature of both cross-linking and chain-fracturing reactions, there is a possibility that the dissociation stage may also be involved.

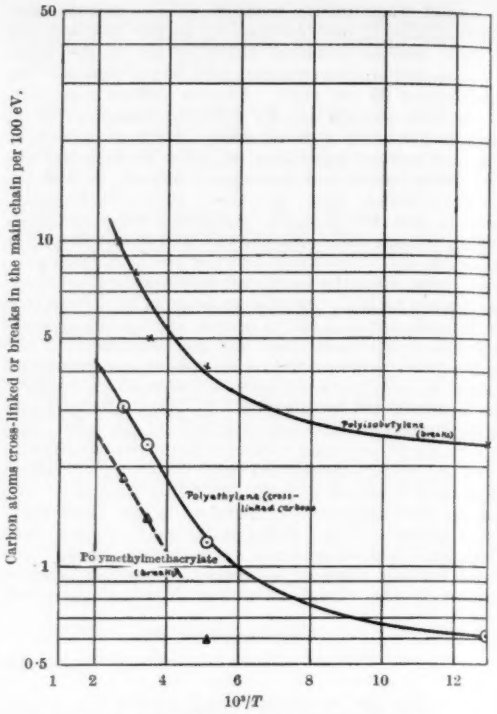

Fig. 2. Effect of irradiation temperature upon cross-linking and chain fracture in vinyl polymers

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[1] Alexander, P., Charlesby, A., and Ross, M., *Proc. Roy. Soc.*, A, **223**, 392 (1954).
[2] Alexander, P., Black, R. M., and Charlesby, A., *Proc. Roy. Soc.*, A, **232**, 31 (1955).
[3] Charlesby, A., *Proc. Roy. Soc.*, A, **215**, 187 (1952).
[4] Charlesby, A., and Hancock, N. H., *Proc. Roy. Soc.*, A, **218**, 245 (1953).
[5] Birks, J. B., *J. Chem. Phys.*, **20**, 1655 (1952).

LETTERS TO THE EDITORS

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Effects of Ionizing Radiations on Serum Complement and Enzymes

ANIMALS exposed to ionizing radiations almost invariably have a lowered resistance to bacterial infection. The serum complement system which aids lysis of invading bacteria is known to be readily inactivated by radiomimetic substances such as nitrogen mustard[1], and it was considered of interest to examine the effects of X-rays and electrons on this system *in vitro*. It was hoped that an investigation of the effect of various types of radiations on the relatively labile complement system might yield useful information about the biological effects of these radiations. The 15-MeV. linear accelerator at St. Bartholomew's Hospital has been used as the source of X-rays and electrons in all our experiments, and guinea pig serum has been used as a source of complement.

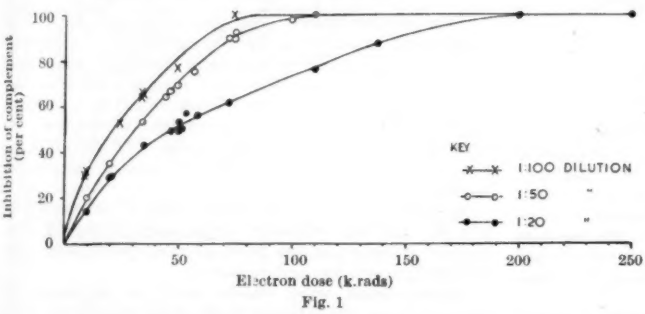

Fig. 1

It has been found that doses of X-rays and electrons up to 200,000 rads have little or no detectable effect, if undiluted serum or strong solutions are irradiated; but when dilute solutions are irradiated, the specific hæmolytic activity of serum complement is destroyed. Fig. 1 shows the inhibition produced by irradiation with electrons as a function of dose and concentration of serum. With a very dilute serum (1 : 100 dilution) some inhibition was observed with as little as 500 rads, and it is considered probable that the enhanced destruction of complement in dilute solutions may be a result of the reduction of concentration of protective substances in the serum.

When using electron irradiation, the mean dose-rate was about 12 million rads per min.; but practically the same results were obtained with X-rays at a dose-rate of about 1,000 rads per min., indicating that the effect is independent of dose-rate.

The percentage inhibition is approximately an exponential function of the dose, but there does not appear to be a simple relationship between the amount of destruction and the degree of serum dilution.

In most of these experiments the diluted serum was irradiated in the presence of air; but irradiation of the serum in a Thunberg tube from which the air had been removed and replaced by nitrogen containing 5 per cent carbon dioxide did not produce a significant change in destruction of the complement in 1 : 20 or 1 : 50 dilution of serum, by an X-ray dose of 50,000 rads.

The destructive effect of X-rays on complement can be partially prevented by the addition of cysteine or cysteamine to the diluted serum before irradiation. For example, a dose of 50,000 rads completely destroyed the complement activity of diluted (1 : 50) serum, but the inhibition was reduced to 48 per cent in the presence of $M/500$ cysteine and to 32 per cent in the presence of $M/500$ cysteamine.

The possibility that complement inactivation by radiation was due to the production of anti-complementary substances in the serum during the irradiation has been examined. Irradiated dilute serum was added to normal serum, and subsequent determination of the total complement titre showed that no long-lived inhibitory substance was present in the irradiated serum.

An examination of the enzymic activity of samples of the irradiated and non-irradiated 1 : 20 and 1 : 50 diluted serum used for the complement tests showed that X-ray doses of 20 and 50 kilorads caused no reduction in the activity of the cholinesterase, lipase or alkaline phosphatase present in the serum. The fact that these enzymes are unaffected by the same conditions in which complement is powerfully inactivated emphasizes the marked selectivity in the biological effects of X-rays. This work is being continued by studying the serum complement and enzyme activity-levels in irradiated guinea pigs and other experimental animals.

Since hæmolytic complement is readily inactivated by nitrogen mustard[1], the results presented here provide a further instance of the similarity in biological effects produced by X-rays and the so-called radiomimetic substances (such as the nitrogen mustards).

These investigations form part of a programme of research carried out with the aid of grants provided by the Treasurer and the Board of Governors from the Discretionary Fund of St. Bartholomew's Hospital. One of us (P. J. H.) is also indebted to the Medical Research Council for a studentship.

P. J. HANDOLL
J. ROTBLAT
E. D. WILLS
A. WORMALL

Departments of
Biochemistry and Physics,
Medical College of
St. Bartholomew's Hospital,
London, E.C.1.
June 12.

[1] Watkins, W. M., and Wormall, A., *Biochem. J.*, **52**, 365 (1952).

Absolute Amount of Ribonucleic Acid in Viruses

ON the basis of work with plant virus strains, Knight[1] expressed the view that all strains of virus contain the same quantity of nucleic acid. Recent experiments have shown that there exist a number of animal viruses which contain only ribonucleic acid. If one plots the percentage of ribonucleic acid against the particle weight of viruses containing ribonucleic

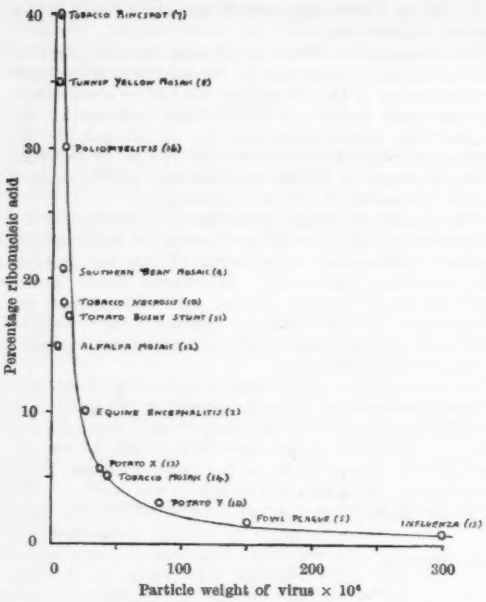

Fig. 1. Percentage of ribonucleic acid in relation to particle weight of viruses containing ribonucleic acid

acid, a hyperbola results. Thus in animal viruses also the absolute amount of ribonucleic acid seems to be the same, and coincides with the quantity found in most plant viruses. As the actual equation of the hyperbola is percentage ribonucleic acid × molecular weight of the virus = 2×10^6, the average weight of the ribonucleic acid in a single virus particle amounts roughly to two million times that of a hydrogen atom.

This amount of ribonucleic acid consists of about 6,000 nucleotides. However, this should not be interpreted to be a single macromolecule comparable to some sort of gene. It has been shown in some strains of plant and animal viruses that there are smaller sub-units containing the total ribonucleic acid in smaller portions. Tobacco mosaic virus can be degraded to about 108 sub-units, still containing 5·5 per cent ribonucleic acid. This sub-unit has a particle weight of 360,000 [2]. If this unit contains only one molecule of ribonucleic acid, the molecular weight of the nucleic acid would be 20,000 and it would contain 60 nucleotides. The sub-unit of the influenza virus containing ribonucleic acid is the soluble antigen with a particle weight of 600,000 and a ribonucleic acid content of 5·3 per cent. About 70 such sub-units were found in an elementary body of the virus[3]. In this case the ribonucleic acid would contain 100 nucleotides. There are about 13 sub-units containing ribonucleic acid in fowl plague virus. These have a particle weight of about 1,300,000 and a ribonucleic acid content of 15 per cent[4,5]. The ribonucleic acid contains about 600 nucleotides.

It is probable that one single virus particle is sufficient to infect the host cell[6]. In spite of the different sizes of the elementary bodies and the different numbers of sub-units containing ribonucleic acid, it seems that it is the absolute amount of ribonucleic acid which is concerned with turning the normal metabolism of the host cell into virus production. This amount seems to be the same for viruses ranging from a particle weight of some millions to some hundreds of millions and acting upon a great variety of hosts—plants as well as animals.

W. Frisch-Niggemeyer

Public Health Laboratory,
Northampton.

[1] Knight, C. A., "Adv. Virus Res.," **2**, 153 (1954).
[2] Schramm, G., "Die Biochemie der Viren" (1954).
[3] Frisch-Niggemeyer, W., and Hoyle, L., *J. Hyg.* (in the press).
[4] Schafer, W., and Zillig, *W., Z. Naturforsch.*, **9b**, 779 (1954).
[5] Schafer, W., and Wecker, E. (personal communication).
[6] Luria, S. E., "General Virology" (1953).
[7] Stanley, W. M., *J. Biol. Chem.*, **129**, 405 (1939).
[8] Markham, R., *Farad. Soc. Disc.*, **11**, 22 (1952).
[9] Miller, G. L., and Price, W. C., *Arch. Biochem.*, **10**, 467 (1946).
[10] Bawden, F. C., "Plant Virus Diseases" (1943).
[11] Stanley, W. M., *J. Biol. Chem.*, **135**, 437 (1940).
[12] Ross, A. F., *Phytopath.*, **31**, 394 (1941).
[13] Bawden, F. C., and Pirie, N. W., *Brit. J. Exp. Path.*, **19**, 66 (1938).
[14] Schramm, G., and Dannenberg, H., *Ber. Chem. Ges.*, **77**, 53 (1944).
[15] Ada, G. L., and Perry, B. T., *Austral. J. Exp. Biol.*, **32**, 453 (1954).
[16] Schwerdt, C. E., and Schaffer, F. L., *Ann. N.Y. Acad. Sci.*, **61**, 740 (1955).

Isotopes incorporated in the Nucleic Acids of *Trypanosoma mega*

The trypanosomes can be cultured in media containing nucleic acids or purines. *Crithidia fasciculata* grows in a synthetic medium with folic acid, guanine or guanosine[1,2]. *Trypanosoma cruzi* has been cultured by Citri and Grossowicz[3] in a defined medium enriched with ribonucleic acid, and its growth is stimulated by guanosine. *T. rhodesiense* seems to need adenine and adenosine as growth factors[4].

In view of these facts, we thought it interesting to try to discover whether trypanosomes could synthesize nucleic purines from simpler precursors such as labelled glycine and formate.

Experiments were made with a trypanosome isolated from the African toad, *Bufo regularis*. This trypanosome is morphologically identical with *Trypanosoma mega*, described by Dutton and Todd, Broden and Rodhain[5]. It has been cultured for more than a year in the medium used successfully by one of us (G. J. B.) for *T. cruzi*. This medium has the following composition: NaCl, 4 gm.; $Na_2PO_4 12H_2O$, 5 gm.; KCl, 0·4 gm.; glucose, 2 gm.; 'Bacto-tryptose Difco', 15 gm.; 'Oxoid' liver infusion, 1 gm.; hæmin, 20 mgm.; twice-distilled water, 1,000 ml.; *p*H adjusted to 7·8. The solution was sterilized by autoclaving for 10 min. at 10 lb. This medium contains large quantities of free purine bases, mainly hypoxanthine.

The trypanosomes were cultured at 24° C. either in roller tubes or in flat-bottomed flasks. After seven days, the culture was centrifuged, the trypanosomes were washed with buffered saline and suspended in culture medium containing a known quantity of labelled precursor (0·25–0·50 μc./ml.). After a period of incubation of 10–50 min. at 24° C., the trypanosomes were killed by ice-cold 1 per cent trichloracetic acid; they were washed several times with a 1 per cent trichloracetic acid solution of a carrier (adenine, formate or glycine, according to the experiments). The ribonucleic acids and deoxyribonucleic acids were hydrolysed and their components analysed by paper chromatography according to the method previously described by one of us (M. S.)[6]. The specific incorporation of the isotopes

was determined in the adenine and in the guanine of both nucleic acids.

Adenine-8^{14}C was rapidly incorporated by *T. mega* for the synthesis of its nucleic acids. Adenine isolated from ribonucleic acid had a specific activity 3–10 times higher than adenine isolated from deoxyribonucleic acid. Adenine was incorporated 4–5 times more rapidly in the adenine-ribotides than in the guanine-ribotides, and about twice as rapidly in the adenine-deoxyribotides as in the guanine-deoxyribotides.

Simpler precursors such as glycine-2^{14}C and formate-^{14}C, even when samples of higher specific activity were used, were not incorporated in the purine bases of trypanosomes, although actively incorporated in their proteins. It seems, therefore, that *Trypanosoma mega* is unable to synthesize the purine nucleus.

The rapid incorporation of free adenine by *T. mega* suggests that the ribonucleic acid contained in the medium of Citri and Grossowicz could be, at least partially, replaced by free bases.

G. J. Boné
M. Steinert

Institut pour la Recherche Scientifique
en Afrique Centrale,
Centre de Recherche du Katanga,
Elisabethville, Congo Belge.
March 27.

[1] Cowperthwaite, J., Weber, M. M., Packer, L., and Hutner, S. H., *Ann. New York Acad. Sci.*, **56**, 972 (1953).
[2] Nathan, H. A., and Cowperthwaite, J., *Proc. Soc. Exp. Biol. Med.*, **85**, 117 (1954).
[3] Citri, N., and Grossowicz, N., *J. Gen. Microbiol.*, **13**, 273 (1955).
[4] Williamson, J., and Rollo, I. M., *Nature*, **170**, 376 (1952).
[5] Laveran, A., and Mesnil, F., in "Trypanosomes et Trypanosomiases" (Masson, Paris, 1912).
[6] Steinert, M., *Biochim. Biophys. Acta*, **18**, 511 (1955).

Metabolism of Isolated Liver Cells

Longmuir and ap Rees[1] have recently described a new method for preparing suspensions of isolated rat liver cells. We have been interested for some time in the metabolic properties of such isolated cells, and wish to direct attention to some of their peculiarities not mentioned by these authors.

Four methods are now available for preparing such material: (*a*) simple squeezing or crushing of the liver tissue; (*b*) the method of Anderson[2], in which the cells are loosened by a preliminary perfusion of the organ with a calcium-free solution containing citrate or versene, with subsequent squeezing of the tissue as in (*a*); (*c*) the method of Kaltenbach[3], in which the tissue without previous treatment is pushed through sieves of increasingly fine mesh; and (*d*) the method of Longmuir and ap Rees[1], in which the minced tissue is incubated in a slightly acid medium (*p*H 5–6) and then disrupted by violent agitation. In all four methods a large proportion of the cells is broken, and the remaining whole cells are obtained free from cytoplasm, cytoplasmic particles, nuclei, debris and red blood cells by differential centrifugation. The yield of isolated cells obtained by the different methods varies very widely, that of Anderson giving in our hands a yield incomparably better than any of the others (Table 1); moreover, this method invariably yields suspensions consisting almost exclusively of single cells, whereas those

Table 1. Total Dry Weight of Isolated Rat Liver Cells obtained by Four Different Methods

Method of preparation	No. of exps.	Average yield of cells (mgm. dry wt./rat liver)
1. Simple washing	2	20
2. Method of Anderson (ref. 2)	13	190
3. Method of Kaltenbach (ref. 3)	3	18
4. Method of Longmuir and ap Rees (ref. 1)	3	12

obtained by the other methods we have found to be frequently contaminated with cell clumps.

The outstanding characteristic of these isolated cells, by whichever method prepared, is a complete absence of respiration, and no addition to the medium so far tested will restore this capacity (glucose, pyruvate, citrate, cytochrome *c*, adenosine triphosphate, blood serum and a liver extract freed from mitochondria have been added; 2 : 4-dinitrophenol also does not elicit any respiratory activity). Kaltenbach[3] has stated that cells prepared by his method show a respiration not dependent on the addition of succinate, but does not indicate its magnitude; this we have not been able to confirm.

Further, the isolated cells have lost their capacity to convert intracellular glycogen to lactic acid. The only metabolic processes associated with catabolism which remain are those of succinoxidase and fumarase. The succinoxidase activity is of similar magnitude in cells prepared by all four methods (Table 2) and is greatly augmented compared with the values found in the original tissue; it is not affected by the addition of cytochrome *c*. In several batches of cells Q_{O_2} values in the range -140 to -160 have been observed, and these are higher than can be accounted for by the activity of the isolated mitochondria[4]. It appears, therefore, that the mitochondria *in situ* are more active in this respect than when isolated in hypertonic sucrose solution.

Table 2. Endogenous Respiration and Succinoxidase Activity of Liver Cells, in Slices and in Suspension

Condition of cells	Method of preparation	No. of exps.	Q_{O_2} (endogenous)	Q_{O_2} (succ.)
Slices	—	8	−11·1	−26·2
Isolated cells	Crushing	2	−0·3	−68
,,	Anderson (ref. 2)	11	−0·2	−113
,,	Kaltenbach (ref. 3)	2	0	−73
,,	Longmuir and ap Rees (ref. 1)	2	0	−88

Longmuir and ap Rees[1] give a figure of -18 for the Q_{O_2} of their cells in the presence of succinate. This is about one-sixth of the figure we have obtained, and the discrepancy may perhaps be explained by the following facts. The Q_{O_2}(succ.) of the cells is maximal only at high succinate concentrations (0·025 *M*), and only if the cell concentration in the test mixture exceeds a critical value which is of the order of 1·5 mgm. dry weight/ml. (Table 3). The

Table 3. Relationship between Cell Concentration and Q_{O_2}

Concentration of cells (mgm. dry wt./ml.)	Q_{O_2} (succ.)
0·52	−2
1·03	−70
1·55	−90
2·5	−96
3·6	−107
5·2	−96

succinoxidase activity which is lost on dilution of the cells may be restored by the addition of an extract of liver cells, but not by cytochrome *c*.

We believe the most interesting part of these observations is the complete loss of endogenous metabolism in isolated liver cells, by whatever method they are prepared, and are anxious to discover the nature of the change in the cells which leads to this result. By contrast, it is well known that isolated tumour cells of various ascites tumours are still capable of catabolizing, and at an increased rate compared with the same tumour grown in the solid form.

J. O. Laws
L. H. Stickland

Department of Experimental Pathology
and Cancer Research,
School of Medicine,
University of Leeds.
June 15.

[1] Longmuir, I. S., and ap Rees, W., *Nature*, **177**, 997 (1956).
[2] Anderson, N. G., *Science*, **117**, 627 (1953).
[3] Kaltenbach, J. P., *Exp. Cell Res.*, **7**, 568 (1954).
[4] Hogeboom, G. H., Schneider, W. C., and Pallade, G. E., *J. Biol. Chem.*, **172**, 619 (1948).

Salicylate and Carbohydrate Metabolism

We have observed that when rat diaphragms are incubated aerobically in the medium of Sacks and Sinex[1] with 5×10^{-3} *M* salicylate the amounts of creatine phosphate and adenosine triphosphate in the tissue are significantly reduced and the inorganic phosphorus increased (Table 1).

A possible explanation of these results is that salicylate interferes with oxidative phosphorylation processes and inhibits the synthesis of high-energy phosphate bonds. Support for this view is provided by the similarity between the effects of salicylate and 2 : 4-dinitrophenol, which is known to interfere with oxidative phosphorylation reactions[2]. Both salicylate and dinitrophenol increase the oxygen consumption of whole animals and isolated tissues[3,4] and dinitrophenol also reduces the creatine phosphate and adenosine triphosphate in the rat diaphragm[1,5].

5×10^{-3} *M* salicylate has been observed[6] to decrease the glycogen and increase the lactic acid production and the respiratory quotient of the rat diaphragm, and these changes may be evidence of substrate being broken down to provide energy for increasingly inefficient phosphorylation processes. The decreased glucose uptake also found in the diaphragms in the presence of salicylate is explicable on the same basis if the first step in glucose utilization involves phosphorylation.

The concept that salicylate may prevent the normal synthesis of high-energy phosphate bonds and hence impair the general efficiency of synthetic processes may also provide an explanation of some of the effects of the substance on carbohydrate metabolism in animals. The subcutaneous injection of salicylate, producing plasma salicylate concentrations of the order of 5×10^{-3} *M*, causes a marked depletion of the blood glucose concentration of the fasted alloxan-diabetic rat[7]. In this animal preparation the blood glucose-level is maintained by synthetic reactions, the increased liver glucose-6-phosphatase activity present[8] producing hyperglycæmia rather than deposition of liver glycogen. The hypoglycæmic effect of salicylate may therefore be due to an impairment of synthetic ability caused by an interference with the formation of high-energy phosphate bonds. Similar considerations may apply to the effect of salicylate in causing a depletion of the liver glycogen in the normal rat[9] although adrenaline release may also be an important factor[10].

Full details of the experiments described above will be published elsewhere.

M. J. H. Smith
S. W. Jeffrey

Department of Chemical Pathology,
King's College Hospital Medical School,
Denmark Hill,
London, S.E.5.
April 24.

[1] Sacks, J., and Sinex, F. M., *Arch. Biochem.*, **39**, 205 (1952).
[2] Loomis, W. F., and Lipmann, F., *J. Biol. Chem.*, **173**, 907 (1948).
[3] Meade, B. W., *Ann. Rheumat. Dis.*, **13**, 60 (1954).
[4] Sproull, D. H., *Brit. J. Pharmacol.*, **9**, 262 (1954).
[5] Barnes, J. M., Duff, J. I., and Threlfall, C. J., *J. Physiol.*, **130**, 585 (1955).
[6] Smith, M. J. H., and Jeffrey, S. W., *Biochem. J.*, [**63**, 524 (1956)].
[7] Bornstein, J., Meade, B. W., and Smith, M. J. H., *Nature*, **169**, 115 (1952).
[8] Langdon, R. G., and Weakley, D. R., *J. Biol. Chem.*, **214**, 167 (1955).
[9] Lutwak-Mann, C., *Biochem. J.*, **36**, 706 (1942).
[10] Smith, M. J. H., *Brit. J. Pharmacol.*, **10**, 110 (1955).

Table 1. Effect of 5×10^{-3} *M* Salicylate on the Inorganic Phosphorus, Creatine Phosphate and Adenosine Triphosphate of the Rat Diaphragm incubated Aerobically

Mean values ± *S.D.* and ranges are given for the results, which are expressed as mgm. inorganic phosphorus/100 gm. wet weight. The figures in brackets represent the number of experiments

	Inorganic phosphorus			Creatine phosphate			Adenosine triphosphate		
Time (min.)	15 (8)	30 (12)	60 (11)	15 (8)	30 (12)	60 (11)	15 (8)	30 (6)	60 (8)
Control	23·2±3·7 18·1–29·3	25·5±3·7 20·2–31·3	25·7±4·0 19·8–32·1	22·6±3·4 18·4–29·3	19·1±3·6 13·0–24·1	18·4±4·8 10·6–24·1	27·9±4·4 21·7–34·4	20·9±3·8 16·6–27·0	24·3±3·4 18·4–27·5
Salicylate	51·6±3·6 46·9–55·5	41·8±4·2 35·4–47·7	36·4±4·6 30·0–41·4	1·5±2·5 0–7·5	3·5±2·9 0–7·0	3·8±2·0 1·0–6·7	14·3±6·0 3·8–25·2	3·9±2·9 0–7·7	7·6±2·7 5·2–12·2

Statistical comparison between the results of the control and salicylate groups showed that $P < 0.001$ at each point

Elastomucoproteinase and Collagen-mucoproteinase, the Mucolytic Enzymes of the Pancreas

The elastolytic enzyme of human and animal pancreas which we have named elastase[1–4] seemed to be specific for elastic fibre[5], but apparently had no effect on native collagen fibre. Hall, Reed and Tunbridge[6] have shown that elastase preparations have some effect on the mucopolysaccharide of elastin also, and during digestion sulphate and polysaccharide components are split off from elastin. Hall[7] suggests the existence of two enzymes acting on elastin, having evidence that one of these must be regarded as a mucolytic one. Partridge and Davis[8] determined the release of N-terminal residues from elastin by elastase

and concluded that elastase preparation contains a proteolytic component also.

Our recent experiments have proved that elastase preparation purified to a high degree is still not homogeneous but consists of several protein components. We wish to retain the name 'elastase' for the enzyme which has a proteolytic effect on elastin. So, according to this nomenclature, the elastase is a proteinase. Banga[3] has shown that besides elastase the pancreatic extract contains an enzyme which acts on the mucoprotein of human sera and is different from the mucolytic enzyme acting on elastin. Here we wish to report some new findings which show that pancreatic extracts do contain enzymes acting on the mucoproteins of connective tissues. Two enzymes will be described, which seem to be distinct from each other. One acts on elastomucin and the other splits the mucoprotein from native collagen fibre. The first may be called elastomucoproteinase and the other collagenmucoproteinase.

The polysaccharide of both the mucoproteins of elastin and collagen was determined by the quantitative method of the Molisch reaction worked out by Szára[10] and used by Bagdy and Szára[11] for the examination of the polysaccharide of fibrinogen. With this method 10–100 μgm. sugar can be determined in an exact manner. The reagent 1-naphthol-2-sulphuric acid is soluble in water, and with glucose, galactose and mannose gives the same mauve colour with uniform intensity. Mucoproteins, enzymatically split from elastin and collagen, react with the reagent but give different colours. The polysaccharide of elastomucin turns from mauve to red with increasing concentration, but the mucoprotein which is split off enzymatically from native collagen fibres reacts with orange-yellow colour. These two different colours prove the difference of the polysaccharide components building up elastomucin and the mucoprotein of collagen respectively. The deviation in colour from the known hexoses indicates that the composition of the mucopolysaccharides of elastin and collagen is not homogeneous and contains unknown components also.

The quantity of the mucoproteins of collagen and elastin which split off enzymatically were determined using concentration curves obtained empirically against a blank. Since these curves are straight lines for concentrations between 10 and 100 μgm. and conform to the monosaccharide of adequate quantity, we inferred that we could calculate the plausible value of these mucopolysaccharides.

The substrate for measuring the elastomucase activity was the preparation of lig. nuchae also used by Hall[7] which was freed from collagen by boiling with acetic acid. The elastomucoproteinase splits off the elastomucin from this preparation. 20–25 per cent of this polysaccharide was dialysed against water, from which we concluded that at least a part of the polysaccharide is present as a component of low molecular weight. The *p*H optimum for elastomucase is 7·3–7·4. The *p*H curve could not be determined in an exact manner in alkaline *p*H because the elastomucin is hydrolysed from the elastin at this *p*H without enzyme too. On the other hand, at alkaline *p*H the elastase which is present in small quantity displays its proteolytic activity also.

For studying the activity of collagenmucoproteinase, collagen fibres of rat-tail tendon and of bovine Achilles tendon were used.

The collagenmucoproteinase dissolves a mucoprotein from the native collagen fibres as well as from the collagen fibres treated with alcohol. The quantity of the dissolved mucoid is 5–8 per cent of the native protein. The polysaccharide content of the mucoprotein is between 8 and 12 per cent, from which 20 per cent can be dialysed against water. The *p*H optimum of the enzyme is 7·4. If the enzyme acts on native collagen fibre the dissolved mucoprotein with 1-naphthol-2-sulphuric acid gives an orange-yellow colour but the mucoprotein dissolved from the alcohol-treated collagen reacts with a red colour. The collagenmucoproteinase has no proteolytic action on collagen and does not dissolve it. The collagen treated with collagenmucoproteinase and afterwards heat-contracted can be dissolved entirely with elastase[12], and the collagenolysate obtained in this way contains 0·20–0·25 per cent polysaccharide, which gives with the above reagent a mauve colour. This observation proves our former suggestion[13] that two kinds of mucopolysaccharide exist in the collagen fibre: that which can be dissolved from the native collagen without dissolving the protein, whereas the other is bound firmly to the protein and can be released only when the collagen is digested.

It seems that the system of the elastase complex contains a whole series of enzymes acting on connective tissue fibres and mucoproteins. These enzymes could not be demonstrated in raw pancreatic extract because of the inhibiting effects of the specific enzyme inhibitors. After purifying the extract these enzymes, which chemically resemble one another closely, can be demonstrated by their specific activity.

I. Banga
J. Baló

1st Department of Pathological Anatomy
and Experimental Cancer Research,
Medical University,
Budapest.
March 20.

[1] Baló, J., and Banga, I., *Z. Path. Bakt.*, **12**, 350 (1949).
[2] Baló, J., and Banga, I., *Nature*, **164**, 491 (1949).
[3] Baló, J., and Banga, I., *Biochem. J.*, **46**, 384 (1950).
[4] Banga, I., and Baló, J., *Nature*, **171**, 44 (1953).
[5] Banga, I., Baló, J., and Nowotny, A., *Z. Vit. Horm. Ferm.*, **2**, 408 (1949).
[6] Hall, D. A., Reed, R., and Tunbridge, R. E., *Nature*, **170**, 264 (1952).
[7] Hall, D. A., *Biochem. J.*, **55**, xxxv (1953).
[8] Partridge, S. M., and Davis, H. F., *Biochem. J.*, **61**, 21 (1955).
[9] Banga, I., 3rd Intern. Cong. Biochem., 4–8 (1955).
[10] Szára, I., *Acta Physiol. Hung.* (in the press).
[11] Bagdy, D., and Szára, I., *Acta Physiol. Hung.*, **7**, 179 (1955).
[12] Banga, I., *Nature*, **172**, 1099 (1953).
[13] Banga, I., and Baló, J., *Acta Physiol.*, **6**, 235 (1954).

Alkaline Phosphatase in the Rabbit Mammary Gland

Strong positive reactions for alkaline phosphatase have been reported in the basket or 'myo-epithelial' cells of the mammary gland of some pregnant and lactating mammals[1,2]. Progressive transfer of this activity from the basket cells to the adjacent capillary endothelium later in pregnancy has also been described[1].

Mammary tissue from pregnant and lactating rabbits, taken 14, 20, 23 and 24 days after mating and 9 and 14 days after parturition, was fixed for 14 hr. in acetone at 4° C., vacuum-embedded in paraffin (m.p. 45° C.) and sectioned at 5 or 15μ. Alkaline phosphatase activity was demonstrated by Gomori's technique[3] or by a modified coupling azo-dye method[4], using the stable diazotates of *o*-dianisidine or

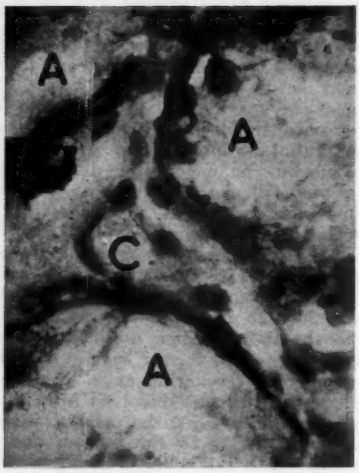

Fig. 1. Mammary tissue from a pregnant rabbit 24 days after mating, incubated with *o*-dianisidine, nuclei coloured by the Feulgen reaction. Parts of three alveoli (*A*) are seen, with the alkaline phosphatase reaction limited to the basket cells. Between them lies a capillary (*C*) the walls of which show a negative reaction. (× 900)

4-chloro-*o*-anisidine, with sodium α-naphthyl phosphate as the substrate. Following incubation some of the sections were treated by the *PAS* technique[4] and in others the nuclei were demonstrated by the Feulgen reaction. These procedures facilitated the accurate localization of the phosphatase reaction without causing any apparent loss of intensity or diffusion of the precipitate compared with untreated sections.

All the samples of tissue except that taken 14 days after mating gave a strong positive reaction after 5 min. incubation with the diazotate; in the latter sample alveolar development was still slight, and the reaction faint. The coloration obtained was sharply limited to the basket cells in all cases, and absent from all nuclei, true alveolar cells, capillary walls and stroma (Fig. 1). Increasing periods of incubation up to 15 min. increased the intensity of coloration but did not affect its location.

The Gomori preparations showed in addition to intense darkening of the basket cells some slight and variable darkening of nuclei, capillary walls and stroma, which became more marked as the incubation time was increased up to 3 hr.; control sections showed no reaction.

It is considered that in the rabbit the alkaline phosphatase of the mammary gland is confined to the basket cells throughout pregnancy and lactation, and that there is no transfer of activity from these cells to the adjacent capillary endothelium in the later part of pregnancy. Rapid embedding in low melting-point paraffin enables alkaline phosphatase activity to be demonstrated with short incubation times, and minimizes diffusion artefacts.

R. L. Holmes

Department of Anatomy,
University of Leeds.
May 3.

[1] Dempsey, E. W., Bunting, H., and Wislocki, G. B., *Amer. J. Anat.*, **81**, 309 (1947).
[2] Silver, A., *J. Physiol.*, **125**, 8*P* (1954).
[3] Gomori, G., *J. Cell. Comp. Physiol.*, **17**, 71 (1941).
[4] Pearse, A. G. E., "Histochemistry" (Churchill, London, 1953).

Properties and Composition of the Bile Pigment giving a Direct Diazo Reaction

The bile pigment, giving the van den Bergh reaction with the diazo reagent in the absence of organic solvents, displays highly polar properties. Conjugated deoxycholic acid has been erroneously supposed to be a component which imparts to this pigment these properties (water-solubility, chloroform-insolubility, electrophoretic mobility, etc.)[1]. This statement was made on the basis of experiments with a preparation from bile containing a large excess of bile salts.

Further experiments[2] concerning the action of enzymes on the directly reacting bile pigment showed the splitting of the bilirubin from the 'direct' pigment under the influence of spleen or bacterial β-glucuronidase and of liver and pancreatic esterases. These enzymic reactions suggest the presence of glucuronic acid in this pigment. The extreme lability toward alkalis is in favour of the ester glucosidic linkage.

In order to prove the presence of glucuronic acid in the direct pigment, the crude preparation from bile (obtained by fractionated precipitation with acetone and rich in this pigment) was purified by reprecipitation with acetone and hydrolysed with ammonia at room temperature. Ammonia was removed *in vacuo* over sulphuric acid and the glucuronic acid was demonstrated by paper chromatography and colour reactions. The bile acids and the ninhydrin-positive material present in the preparation obtained from bile, with the aid of acetone, can be essentially removed. The pigment was precipitated from the solution of this preparation from dog bile by lead acetate and the washed precipitate has the composition corresponding to lead bilirubinyl-*bis*-(β-glucoside uronate)[3].

Billing and Lathe simultaneously came to the same conclusion; but different methods were used in their experiments[4]. Thus, the composition of the directly reacting pigment from bile is now confirmed by independent experiments from both sides.

Ed. Talafant

Department of Medical Chemistry,
Masaryk University,
Brno.
May 24.

[1] Talafant, Ed., *Coll. Czech. Chem. Comm.*, **19**, 1344 (1954).
[2] Talafant, Ed., *Chem. Listy*, **50**, 817 (1956).
[3] Talafant, Ed., *Chem. Listy*, [**50**, 1329 (1956)].
[4] Billing, Barbara H., and Lathe, G. H., *Biochem. J.*, **63**, 6*P* (1956).

An Unfavourable Effect of Shaking on Fungal Cellulases

Shaking in some form or other is often resorted to during the incubation of enzymes with their substrates in order to obtain uniformity of results and a high rate of enzyme activity. In studies with insoluble cellulosic substrates this has been the usual practice among various workers. However, in an investigation of the cellulolytic activities of the culture filtrates of some fungi, preliminary experiments indicated that no advantage was to be gained by shaking, either in uniformity or in rate of enzyme activity, and that shaking might actually be harmful. Some of these experiments are summarized below; fuller details will be published elsewhere.

The culture filtrates were prepared by growing six cellulose-decomposing fungi on Czapek–Dox salt

solution with filter paper as carbon source, at 30° C. for 6–9 days; the stale medium, after filtering through fritted glass, was used as the source of enzyme. The substrates were reactive cellulose, prepared by treating cotton linters with phosphoric acid as described by Walseth[1], and sodium carboxymethyl-cellulose, in the form of 'Cellofas *B*', which was dissolved in hot water before use.

Hydrolysis was carried out in 125-ml. duplicate 'Pyrex' conical flasks, each containing 200 mgm. substrate, 2 ml. enzyme and 10 ml. *M*/10 acetate buffer at *p*H 5·0 saturated with the antiseptic pentachlorophenol; the volume was made up to 20 ml. with distilled water. After incubation at 37° C. for 3 hr., 5 ml. of the hydrolysate was withdrawn and titrated for reducing sugar, according to Somogyi's micro-method[2]. The titres were corrected by subtracting the blank titres for substrate alone and enzyme alone.

One set of flasks was incubated in a water-jacketed electrical incubator and the other set clamped to a movable metal frame situated above a thermostatically controlled water-bath; the bottom parts of the flasks were submerged in water and the shaking frame moved with a to-and-fro motion parallel to the water surface across a distance of 0·9 in. with 130 strokes per minute in each direction. In both incubator and water-bath, variation in temperature was well within ± 0·5 deg.

It was found that shaking decreased the hydrolysis of both substrates by all the enzyme solutions (Table 1). Moreover, unshaken flasks gave equally concordant titres. These results were confirmed by repeated experiments in which the time and temperature factors were carefully equalized between incubator and water-bath.

Another experiment indicated that this effect might be partly due to the inactivation of the cellulase enzyme molecule itself by shaking. In this experiment, the six enzyme solutions were first incubated without substrate, with and without shaking, for 3 hr. at 37°; from these, 1 ml. quantities were then reincubated with reactive cellulose as usual. The results given in Table 2 show that enzyme solutions previously shaken were less active than the unshaken ones.

For the sake of comparison, the activities of three other enzymes in a fungal extract prepared from *Aspergillus oryzae* were studied in the shaken and unshaken states. These were invertase, amylase and proteinase, with sucrose, starch and gelatin as substrates. No effect of shaking was observed, except with amylase, which registered a 10 per cent fall in titre in the shaken flasks, after incubation for 3 hr. Equally concordant results were obtained with and without shaking in every case.

Table 1. Enzyme Titres (ml., *N*/200 Thiosulphate) With and Without Shaking

Fungus	Sodium carboxymethylcellulose		Reactive cellulose	
	Without shaking	With shaking	Without shaking	With shaking
Curvularia lunata	4·25 4·15	1·55 1·60	1·70 1·70	0·80 0·90
Aspergillus fumigatus	10·15 10·25	8·35 8·50	1·95 2·00	1·90 1·95
Chaetomium indicum	8·80 —	2·15 2·40	0·80 0·75	0·70 0·65
Penicillium rubrum	11·50 11·40	7·35 7·25	1·95 2·05	1·70 1·80
Penicillium wortmanni	13·05 12·90	12·01 12·15	1·45 1·50	0·95 0·80
Myrothecium verrucaria	4·55 4·55	2·55 2·45	— —	— —

Table 2. Effect of Previous Shaking of Cellulase Solutions on Enzyme Titre

Fungus	Titre (ml., *N*/200 thiosulphate)	
	Not shaken	Previously shaken
Curvularia lunata	13·50 13·65	10·60 10·40
Aspergillus fumigatus	4·85 4·80	4·15 4·05
Chaetomium indicum	1·65 1·75	1·35 1·45
Penicillium rubrum	9·40 9·40	7·80 7·75
Penicillium wortmanni	1·60 1·80	0·95 0·90
Myrothecium verrucaria	0·65 0·60	0·55 0·60

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S. N. Basu
P. N. Pal

Microbiology Section,
Indian Jute Mills Association Research Institute,
Calcutta.
April 4.

[1] Walseth, C. S., *Tappi*, **35**, 228 (1952).
[2] Somogyi, M., *J. Biol. Chem.*, **160**, 61 (1945).

Enzymatic Formation of Hexosamine in Epiphyseal Cartilage Homogenate

Chondroitin sulphate, or its protein complex, may be an integral part of the process of calcification[1,2]. Sulphate-containing mucopolysaccharides appear whenever calcification takes place.

According to Neuman *et al.*[3] and Caglioti *et al.*[4] calcium should be bound to the molecule of chondroitin sulphuric acid by one valence of the sulphuric group.

Rubin and Howard[5] found an increase in metachromatic staining in regions where there is active calcification, and attributed this effect to an increase in the concentration of chondroitin sulphate or a change in its degree of polymerization; however, the chondroitin sulphate is modified by the cells during the first stage of calcification. For this reason we have decided to study chondroitin sulphate metabolism in epiphyseal cartilage, beginning with the formation of hexosamine which is a component of chondroitin sulphate.

A preliminary report of this work has already appeared[6].

Work by Leloir and Cardini[7] has shown that hexosamine may be derived from glutamine and hexose-6-phosphate. An enzyme system catalysing this synthesis has been found in *Neurospora crassa*. As significant amounts of hexose-6-phosphate and glutamate are present in the epiphyseal cartilage, a similar enzymatic mechanism was supposed by us to exist in cartilage homogenate.

Epiphyseal cartilage of growing rabbits was used. The tissue was excised at 0° C., and homogenized with a cold solution of 10^{-2} *M* glutamine and 10^{-2} *M* glucose-6-phosphate in 0·1 *M* citrate buffer (*p*H 6·4). Test-tubes were incubated at 30° C. for 3 hr. The

enzymatic reaction was blocked by immersion in boiling water for 10 min. and the addition of hydrochloric acid. The final concentration of the acid was 0·3 *N*. The hexosamine present in the supernatant liquids before and after incubation was estimated by Schloss's method[8].

These experiments have shown that epiphyseal cartilage homogenates can synthesize very large quantities of hexosamine (*c.* 900γ per gm. of fresh tissue during 3 hr.). This activity is destroyed by immersion of homogenates in boiling water.

Other tissues have been investigated with regard to their ability to synthesize hexosamine: rib cartilage, liver and lung homogenates showed synthesis of very small amounts of hexosamine. Heart, kidney, and spleen homogenates and blood were completely inactive.

We may therefore conclude that a thermolabile enzymatic system, catalysing the synthesis of hexosamine from glutamine and glucose-6-phosphate, is present in epiphyseal cartilage. The enzymatic activity is much greater in this tissue than in others (about ten-fold). For this reason we could consider this enzyme a part of the "local factor(s)" (Sobel[9]) connected with the mechanism of calcification.

Recently a report has been published by Boström *et al.*[10] concerning the influence of glutamine in chondroitin sulphate synthesis in slices of cartilage. Our findings, regarding the formation of hexosamine, and those of Boström *et al.*, regarding the catalytic action of glutamine in chondroitin sulphate synthesis, are essentially in agreement. In fact, hexosamine could constitute an intermediate point in the synthesis of chondroitin sulphate.

Work is being carried out to determine whether, in our experiments, there is an increase in the amount of chondroitin sulphate, utilizing the hexosamine formed by the aforementioned enzyme.

Alessandro A. Castellani
Vittorio Zambotti

Institute of Biochemistry,
University of Pavia.
March 13.

[1] Miller, Z. B., Waldman, J., and McLean, F. C., *J. Exp. Med.*, **95**, 497 (1952).
[2] Sobel, A. E., and Burger, M., *Proc. Soc. Exp. Biol. and Med.*, **87**, 7 (1954).
[3] Neuman. W. F., Boyd, E. S., and Feldman, I., Trans. Macy Conf. on Metabolic Interrelations, **4**, 100 (1953).
[4] Cagliotl, V., Ascenzi, A., and Scrocco, M., *Arch. Sci. Biol.*, **39**, 116 (1955).
[5] Rubin, P. S. and Howard, J. E., Trans. Macy Conf. on Metabolic Interrelations, **2**, 155 (1950).
[6] Castellani, A. A., Perri, G. C., and Zambotti, V., 24th Congress S.I.B.S., Roma, September (1955); *Boll. S.I.B.S.* (in the press).
[7] Leloir, L. F., and Cardini, C., *Biochim. Biophys. Acta*, **12**, 15 (1953).
[8] Schloss, B., *Anal. Chem.*, **23**, 1321 (1951).
[9] Sobel, A. E., *Ann. New York Acad. Sci.*, **60**, 713 (1955).
[10] Boström, H., Roden, L., and Vestermark, A., *Nature*, **176**, 601 (1955).

A Rapid Method for estimating Total Protein in Milk

In 1944, Fraenkel-Conrat and Cooper[1] determined the acid-binding capacities of several proteins by treating the protein with an excess of an anionic dye, orange *G*, at a *p*H of 2·2. The dye and protein react quantitatively to form an insoluble complex which can easily be separated either by centrifuging or filtering. (Ordinary filter paper binds a small amount of dye which must be accounted for to obtain accurate results.) From the concentration of unbound dye (measured colorimetrically), the binding capacity can be calculated. Using this method in principle in an investigation designed to determine the acid-binding capacities of several protein fractions derived from wheat flour, I[2] noted an unexpected uniformity in the binding capacity of mixtures of the two major fractions as obtained from each of several varieties of wheat. These two individual protein fractions have binding capacities differing by a factor of nearly two.

The foregoing observation prompted a study of the binding capacities in whole wheat and wheat flour which led to the conclusion that when the total proteins of either of these products are taken collectively, these proteins can be characterized by a single binding capacity value. Although starch and bran of wheat also bind some dye, the total protein in whole wheat and wheat flour can be conveniently measured by this technique. (A detailed account of this work has recently been published[3]. Application has been made for a public patent.)

An extension of this general technique to the determination of total protein in milk products has been made. The assumption that the total protein in milk also has a common binding capacity is substantiated by the results of tests on more than one hundred samples of milk.

Samples of fresh whole milk and spray-dried milk were obtained from the dairy herd at the State College of Washington through the courtesy of the Department of Dairy Science. Two series of measurements were made. In the first, 1·5 ml. aliquots of fresh milk were mixed with 25·0 ml. of buffered orange *G* dye. The concentration of added dye was 1 gm./l. After being shaken for 5 min., the mixture was centrifuged. The concentration of unbound dye in the clear supernatant was measured in a special absorption cell of short light-path (a note describing this cell has been submitted to *Analytical Chemistry* for publication) using a 470-mμ filter in an Evelyn photoelectric colorimeter. Galvanometer readings were estimated to the nearest 0·1 per cent transmission.

Results of tests on seventy-three samples of liquid whole milk from Holstein, Jersey and Guernsey breeds of dairy cows are presented in Fig. 1. The protein values (N × 6·38) were determined by a standard macro-Kjeldahl procedure in routine analyses by the Dairy Science Department.

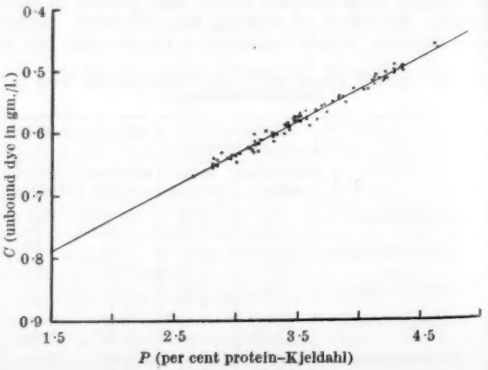

Fig. 1. Relationship between protein content of liquid whole milk and the concentration of unbound dye at equilibrium. Standard error of estimate is 0·07 per cent protein

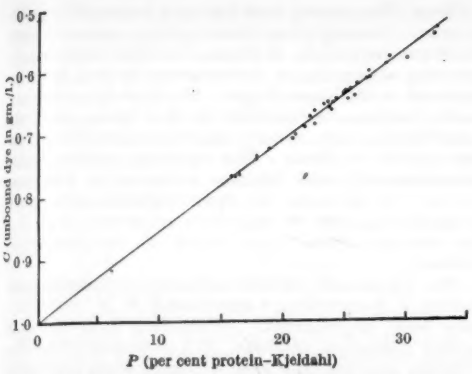

Fig. 2. Relationship between protein content of spray-dried milk and the concentration of unbound dye at equilibrium. Standard error of estimate is 0·42 per cent protein

A second series of measurements was made on thirty-four samples of spray-dried milk. The butter-fat content was altered in some of these samples before spray drying. Except for the size of sample (200 mgm.) and the time of shaking (30 min.), the procedure was unaltered. The ratio of protein to dye was adjusted in each series so that the concentration of unbound dye did not drop appreciably below 0·5 gm./l. Quantitative binding is not obtained if the concentration of dye becomes too dilute. The results are shown in Fig. 2.

Evidently the only constituents binding the dye are the milk proteins, since a line drawn through the experimental points passes very near the origin. In Fig. 1 the origin is different from that in Fig. 2 because of the diluting effect of the added liquid sample (see equation 3 below). A general equation expressing the protein content can be written as follows :

$$P = \frac{100\,[VC_0 - (V + v)\,C]}{kEvd} \qquad (1)$$

where P is the percentage protein, V is the ml. of stock dye solution added, v is the ml. of milk added, C_0 is the concentration of stock dye in gm./l., C is the concentration of unbound dye at equilibrium, k is the equivalent weight of the dye (226 gm.), E is the milliequivalents of dye bound per gram of milk protein, and d is the density of the milk sample.

In the case where the sample is solid, $(v \times d)$ in the denominator is replaced by W (the weight of the sample in gm.) and the value of v in the numerator is zero. We then have the equation :

$$P = \frac{100\,V\,(C_0 - C)}{kEW} \qquad (2)$$

When equation (1) is solved for C, we get :

$$C = \frac{VC_0}{(V + v)} - \frac{kvdE}{100\,(V + v)}\,P \qquad (3)$$

This is the equation of a straight line, and as plotted in Figs. 1 and 2, C is the ordinate, P the abscissa, $VC_0/(V + v)$ the intercept, and the coefficient of P is the slope.

Treatment of the results by the method of least squares gave slope values of 0·1043 and 0·01455, respectively, for the data in Figs. 1 and 2. From these slopes, the respective values of E were computed. For liquid whole milk E is 0·792 and for spray-dried milk E has a value of 0·805. The small difference can probably be attributed to denaturation occurring during the processing of spray-dried milk. These values are close to those reported in the literature[4] for casein.

Doyle C. Udy

Field Crops Research Branch,
Agricultural Research Service,
U.S. Department of Agriculture,
Pullman, Washington.
April 30.

[1] Fraenkel-Conrat, H., and Cooper, Mitzi, *J. Biol. Chem.*, **154**, 239 (1944).
[2] Udy, D. C., *Cereal Chem.*, **31**, 389 (1954).
[3] Udy, D. C., *Cereal Chem.*, **33**, 190 (1956).
[4] Cohn, E. J., and Edsall, J. T., "Proteins, Amino Acids and Peptides", pp. 354, 459 (Reinhold, New York, 1943).

Fractionation of Human Urinary Gonadotrophins

Follicle-stimulating and interstitial cell-stimulating hormones can be extracted from animal pituitary glands ; but there is little evidence that two such substances can be separated from human urine. Walter[1] suggests that separation is possible, and recent evidence[2] is claimed to show that the levels of the two hormones in human urine vary independently. This evidence was obtained by using two assays simultaneously : one assay is believed to measure the combined effect of both hormones and the other to measure the follicle-stimulating hormone alone[3]. The two assays have now been used for investigating the fractionation of human urinary gonadotrophins.

Three crude extracts were made from pooled human urine by adsorption on kaolin. The urine was from normal and abnormal subjects belonging to the categories shown in Table 1. No subjects were pregnant, and pregnancy would not have been overlooked as they underwent detailed and prolonged observation. The crude extracts were fractionated by the method of Butt and Crooke[4] and fraction B was assayed in terms of fraction A by both methods.

The results (Table 1) show that comparison of the same fractions by the different assays gave significantly different estimates of relative potency in two cases. All assays were of at least four-point design and there was close parallelism between dose-response lines. The results therefore show that human urinary gonadotrophin can provide fractions with different biological activities.

The probable reason for this biological difference is a separation of the gonadotrophins, but the influence of other hormones must be excluded. It is unlikely that prolactin interferes in these assays ; but œstrogen can do so[3]. Both fractions from the young adult women were therefore tested for œstrogen by the method of Butt and Kinnear[5]. The dose given

Table 1

Subjects	Fraction B as percentage of fraction A (95 per cent fiducial limits)	
	Total gonadotrophin assay	Follicle-stimulating hormone assay
Postmenopausal women	21 (11–35)	19 (9–50)
Young adult women	47 (29–66)	20 (15–29)
Men	102 (69–175)	44 (39–50)

to each spayed mouse represented ten times the greatest dose used in the gonadotrophin assays. No œstrogenic effect was detected. There was insufficient material from the men for this test, but in one case at least interference from œstrogen was shown to be unlikely.

The different biological activities of the fractions are therefore considered to demonstrate a partial separation of follicle-stimulating and interstitial cell-stimulating hormones.

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P. S. Brown

Department of Clinical Endocrinology,
Birmingham and Midland Hospital for Women,
Birmingham 11.

[1] Walter, K., *J. Endocrin.*, **13**, xxvi (1956).
[2] Brown, P. S., *J. Endocrin.* (in the press).
[3] Brown, P. S., *J. Endocrin.*, **13**, 59 (1955) and in preparation.
[4] Butt, W. R., and Crooke, A. C., Ciba Foundation Colloquia on Endocrinol., **5**, 44 (1953).
[5] Butt, W. R., and Kinnear, A. A., *J. Endocrin.*, **13**, xxviii (1956).

Restoration of Sodium-deficient Frog Nerve Fibres by an Isotonic Solution of Guanidinium Chloride

It has been known for some time that certain quaternary ammonium ions are able to restore the ability to conduct impulses to the small myelinated and unmyelinated fibres (*B* and *C* fibres) of frog nerve that has become inexcitable in a sodium-free medium. Quaternary ammonium ions do not restore the excitability of the large myelinated fibres (*A* fibres)[1].

It has been found that the guanidinium ion, which also has a tetracovalent nitrogen atom[2], restores to sodium-deficient *A* fibres the ability to conduct impulses, while it fails to restore the excitability of *B* and *C* fibres.

In order to avoid the question as to whether or not the epineurium is an effective diffusion barrier, the experiments have been performed with the spinal roots or with the sciatic nerve after removal of the epineurium. Large bull-frogs have been used throughout. All solutions were 0·11 *N* and were prepared by dissolving the hydrochloride of the substance in redistilled water in 'Pyrex glass' containers. (Years ago, several samples of a commercial preparation of 10 per cent aqueous solution of tetraethyl-ammonium hydroxide, which was marketed by a reputable firm in containers of soft glass, were found in this laboratory to contain sodium ions at the concentration $8–10 \times 10^{-3}$ *N*.) A few drops of sodium-free 0·006 *M* diethanol-dimethyl-ammonium phosphates buffer were added, which usually brought the *p*H of the solution to 7·2–7·3. When not, the *p*H of the solution was adjusted to 7·2–7·4 with diethanol-dimethyl-ammonium hydroxide. Analyses with a flame photometer have shown that the concentration of sodium ions in the test solutions was below 10^{-5} *N*. (Frog nerve fibres become inexcitable in a solution containing sodium ions at the concentration 3×10^{-3} *N* practically as fast as in a sodium-free medium.)

The motor root becomes inexcitable in an inert sodium-free medium (0·11 *N* diethanol-dimethyl-ammonium or choline chloride) in 16–25 min. Judging by the height of the restored spike, guanidinium chloride restores the ability to conduct impulses to approximately 80–90 per cent of the *A* fibres. The sensory root becomes inexcitable in 12–20 min. Guanidinium ions restore approximately 70–80 per cent of the *A* fibres. In both instances the restoring action begins instantaneously and becomes maximal in less than 3 min. The desheathed sciatic nerve becomes inexcitable in 2–4 min. and the guanidinium ions restore approximately 60–80 per cent of the *A* fibres. The restoring action begins instantaneously and becomes maximal in less than 5 min. In all cases the spike duration, the speed of conduction and the relatively refractory period of the restored fibres were found to be practically normal.

The effects of several substituted guanidines—methyl, N,N-dimethyl, *n*-amyl and N,N′,N″-triethyl—have been investigated. (Guanidine hydrochloride, methyl guanidine sulphate, N,N-dimethyl guanidine sulphate and arginine hydrochloride were purchased from Distillation Products Industries, Division of Eastman Kodak Company. *n*-Amyl guanidine sulphate was synthesized by the method used by H. King and I. M. Tonkin[3] for the synthesis of *n*-butyl guanidine sulphate. N,N′,N″-Triethyl guanidine was prepared according to A. W. Hoffmann[4].) Although all the N-substituted guanidines are as strong bases as guanidine itself[5], the substituted guanidines do not restore the excitability of any sodium-deficient nerve fibre. Even more, a 0·11 *N* solution of an N-substituted guanidine renders the nerve fibres inexcitable faster than an inert sodium-free solution, and markedly delays and reduces the restoring ability of guanidine and of sodium ions. To be more specific, after the 0·11 *N* solution of a substituted guanidine has been allowed to act upon the nerve for a few minutes, guanidine is able to restore the excitability of only a discrete number of *A* fibres and only after repeated renewal of the guanidine solution. After the action of 0·11 *N* *n*-amyl guanidine hydrochloride, even sodium ions can restore the excitability of only a fraction of the *A* fibres, and only after long, repeated washing of the nerve with Ringer's solution.

This effect of N-substituted guanidines develops without appreciable depolarization of the nerve fibres, which suggests that it is referable to competitive inhibition of chemical processes in the nerve membrane. As a matter of fact, *n*-amyl guanidine readily blocks conduction of impulses in the presence of sodium. Mixtures were made of a 0·11 *N* solution of *n*-amyl guanidine hydrochloride and of a 0·11 *N* solution of sodium chloride in the proportions 15–85, 25–75 and 40–60 parts. The first solution caused block of conduction in a small number of *A* fibres; the second blocked about half the *A* fibres after having caused a marked reduction in the speed of conduction of all, and the third blocked all the *A* fibres in 12–15 min. In all cases recovery after washing with Ringer's solution was prompt and complete.

Although arginine and *n*-amyl guanidine have the same number of carbon atoms, arginine hydrochloride yields a practically inert sodium-free medium. It causes total inexcitability of the nerve in the usual 2–4 min., and affects the restoring actions of guanidine and of sodium ions, if at all, only slightly.

The facts presented in this communication suggest the thought that in the nerve membrane the N-substituted guanidines do not compete directly with sodium ions, but rather with some guanidine-like nitrogen compound.

In regard to the specificity of the various nitrogen compounds that have restoring effects, the following facts should be mentioned. The excitability of

sodium-deficient frog muscle is not restored by either quaternary ammonium ions[6] or by guanidinium ions[7]. The excitability of crustacean muscle is maintained in sodium-free solutions of quaternary ammonium ions that are inert for frog nerve[8]. The excitability of the plant cell *Nitella*, that has become inexcitable in distilled water, is restored by ammonia, ammonium ions, guanidinium ions and a number of other compounds[9]. Ammonium ions do not restore frog nerve fibres[10] or muscle fibres[11].

L. M. H. Larramendi
R. Lorente de Nó
F. Vidal

Rockefeller Institute for Medical Research,
New York.

[1] Lorente de Nó, R., *J. Cell. Comp. Physiol.*, **33**, Supp. (1949).
[2] cf. Taylor, T. W. J., and Baker, W., "Sidgwick's Organic Chemistry of Nitrogen" (Clarendon Press, Oxford, 1937).
[3] *J. Chem. Soc.*, 1063 (1946).
[4] *Ber. Chem. Ges.*, **2**, 600 (1869).
[5] Angyal, S. J., and Warburton, W. K., *J. Chem. Soc.*, 2492 (1951).
[6] Hagiwara, S., and Watanabe, A., *J. Physiol.*, **129**, 513 (1955).
[7] Führer, H., *Arch. Exp. Path. and Pharm.*, **58**, 1 (1908).
[8] Fatt, P., and Katz, B., *J. Physiol.*, **120**, 171 (1953).
[9] Osterhout, W. J. W., *J. Gen. Physiol.*, **24**, 7 (1941).
[10] Gallego, A., and Lorente de Nó, R., *J. Gen. Physiol.*, **35**, 227 (1951).
[11] Overton, E., *Arch. Ges. Physiol.*, **92**, 346 (1902).

Electrical Activity of the Intrafusal Muscle Fibres

The efferent regulation of sensory discharges in muscle proprioceptors is accomplished by activation of the intrafusal fibres through their motor nerve supply. Contraction of these fibres would produce stretch-deformation of the sensory nerve endings and thereby an increase in the frequency of afferent discharges. In the frog it is achieved mainly by activation of the large-diameter motor axons[1] while in the cat it is elicited only when the small nerve fibres are stimulated[2]. Although the bulk of experimental evidence is quite convincing, it still remains largely indirect because direct observations on intrafusal fibre activity are few.

Some developments in recent years have helped considerably in understanding how the muscular portion of a stretch receptor is capable of modulating the frequency of sensory discharges. Alexandrowicz[3] discovered some special organs in the abdomen of the lobster (*Homarus vulgaris*) which were identified as stretch receptors by Wiersma, Furshpan and Florey[4]. It is possible to study them in complete isolation and under direct microscopic observation. This unique advantage enabled Kuffler[5] and Eyzaguirre and Kuffler[6] to demonstrate that they possess motor nerve fibres which activate either a 'fast', twitch-like bundle or a 'slow' receptor muscle.

The present study was designed to obtain some direct evidence on the behaviour of intrafusal muscle fibres in amphibians. The preparation employed was the muscle extensor longus dig. IV of the Chilean toad (*Callyptocephalus gayi*). The muscle was dissected free and placed in a 'Lucite' dish. It was immersed in Ringer solution covered by a layer of mineral oil. The nerve was lifted into the oil for stimulation and recording with 50μ platinum–iridium electrodes. This thin muscle made a flat and transparent preparation in which details could be easily detected using a combination of dark-field illumination and polarized light. Usually the muscle or the nerve was cut down until a single sensory unit remained discharging. Once the preparation was properly set up, *d*-tubocurarine hydrochloride was added to the bath in concentrations of 1–2 μmol./l. This procedure was employed in order to block extrafusal contractions because it is known that the intrafusal junctions are more resistant to curare than the extrafusal ones[1]. After 30–50 min., complete neuromuscular block was achieved; but the spindles could be seen contracting apparently unimpaired. Thus the intrafusal fibres were impaled with microelectrodes filled with 3 *M* potassium chloride and having a d.c. resistance of 10–60 megohms. The external diameter of the tip was about 0·5μ measured with a water immersion objective and an overall magnification of × 900.

Isolation of the spindle was attempted as the most direct approach; but this procedure inevitably caused destruction of the motor nerve supply to the intrafusal bundles. Therefore these bundles were identified in the following way: (1) Once a critical level of curarization was reached, one or two very tiny filaments remained contracting. Usually it was difficult to see them unless magnifications of × 40–63 were used. The contraction of these filaments was not strictly isometric even when the muscle tendons were firmly gripped by forceps. (2) An increase in the frequency of sensory discharges was observed if, and only if, this filament contracted. (3) Destruction of the muscle filament by a sharp needle, operated by a micromanipulator, always produced disappearance of the contractions and cessation of frequency changes in spite of strong shocks given to the nerve. (4) An excessive dose of curare produced a similar effect. (5) The zone where the contracting filament appeared was marked and histological sections were made. A spindle was invariably found in such a place (Fig. 1). It is concluded, therefore, that this particular muscle filament is a neuromuscular spindle and that the contracting fibres form part of an intrafusal bundle.

Impalement of the intrafusal fibres was usually very difficult due to their small size (around 10μ) and because in most preparations the spindles were deeply embedded in the muscle mass. Success was achieved when these structures were located near the surface. In one experiment several successful penetrations were possible and resting membrane potentials of 61·3–88·6 mV. measured. A single shock

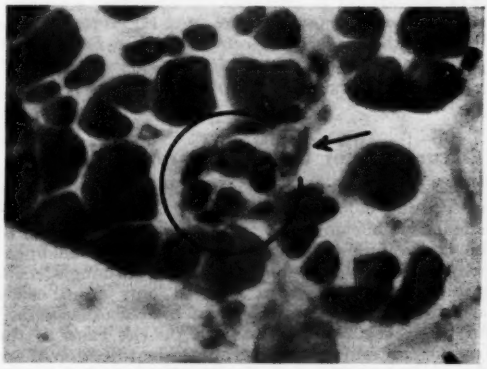

Fig. 1. Muscle strip dissected from extensor longus dig. IV of *Callyptocephalus gayi*. Cross-section made through region where potentials illustrated in Fig. 2 were recorded. This bundle had 70 fibres. Circle, spindle with four intrafusal fibres where intracellular recordings were made; arrow, cross-section of thick myelinated, presumably sensory, axon. (× 500)

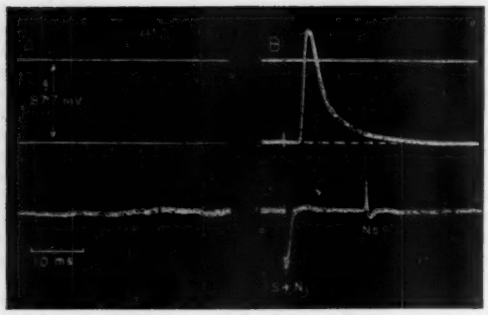

Fig. 2. Electrical activity of neuromuscular spindle. Extrafusal junctions blocked by curare. A single sensory unit was left intact. Upper records in *A* and *B*, intracellular lead from a single intrafusal muscle fibre. Lower records, extracellular electrodes from the nerve. Simultaneous intra- and extra-cellular records.

A, Preparation at rest and under light tension. Resting membrane potential 87·7 mV. Lower record shows no baseline discharge. *B*, After a single nerve shock an action potential of 119·3 mV. is recorded from an intrafusal fibre. Lower record shows artefact plus nerve action potential ($S + N_1$) followed by one sensory discharge (N_2) 15·6 m.sec. after the shock

to the nerve produced action potentials of 84–119·3 mV. and always presenting a positive overshoot of 12·5–31·6 mV. at 21° C. The presence of this spike was always concomitant with an increase in the frequency of sensory discharges (Fig. 2). The characteristics of the action potential indicate that the intrafusal bundles are formed by twitch fibres, innervated by large-diameter motor axons. Nevertheless, the presence of some slow muscle fibres, innervated by the small-nerve motor system, has not been excluded.

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Carlos Eyzaguirre
Juan D. Vial

Laboratory of Neurophysiology and
Department of Anatomy,
Catholic University of Chile,
Santiago, Chile.
April 24.

[1] Katz, B., *J. Exp. Biol.*, **26**, 201 (1949).
[2] Kuffler, S. W., Hunt, C. C., and Quilliam, J. P., *J. Neurophysiol.*, **14**, 29 (1951).
[3] Alexandrowicz, J. S., *Quart. J. Micro. Sci.*, **92**, 163 (1951).
[4] Wiersma, C. A. G., Furshpan, E., and Florey, E., *J. Exp. Biol.*, **30**, 136 (1953).
[5] Kuffler, S. W., *J. Neurophysiol.*, **17**, 558 (1954).
[6] Eyzaguirre, C., and Kuffler, S. W., *J. Gen. Physiol.*, **39**, 87 (1955).

Occurrence of Leuco-anthocyanin in Pears

The anthocyanin pigments of plants may occur in two possible colourless forms, as the pseudo-base and as leuco-anthocyanins[1,2]. In both cases conversion to the corresponding anthocyanin occurs on acidification, but is slower in the latter case. Although leuco-anthocyanins have been isolated only from cacao beans[3] and Australian heartwood of *Acacia melanoxylon*[4] their occurrence is implied on the basis of the vanillin test and chromatographic identification of anthocyanins[2,5]. The occurrence of leuco-anthocyanins in pears (*Pyrus communis*) was suggested by Joslyn[6] to explain the reddening that occurs in tinned pears stacked before they are completely cooled, and by Bate-Smith[1] to explain the reddening of stewed pears. Kiesser *et al.*[7] reported the occurrence of leuco-anthocyanins in perry pears on the basis of chemical and chromatographic examination of the insoluble matter causing haze and turbidity and depositing as a sediment in perry. The red pigment obtained by treatment of the sediment with warm dilute acid was found to contain small quantities of phloroglucinol, protocatechuic acid, catechol and cyanidin but was composed chiefly of complex leuco-anthocyanixs related to cyanidin. We have recently examined Bartlett pears for the occurrence of leuco-anthocyanins and found evidence for the presence of the leuco-anthocyanin related to cyanidin.

Halved ripe California Bartlett pears tested with vanillin reagent[6] gave a strong positive test for leuco-anthocyanin in the core tissue surrounding the seeds and particularly strong reaction in the seeds. The tissue surrounding the seed receptacle gave a less intense and more diffuse reaction. For this reason, the core tissue was separated, ground and extracted first with boiling water, then with absolute methanol. The residue was then extracted with methanol containing 1 per cent hydrochloric acid. This extract, strongly positive to the vanillin test, was brought to 5–10 per cent hydrochloric acid and heated for 5–10 min. The red pigment so obtained was identified by paper chromatography with several solvent systems. The R_F values obtained with butanol–acetic acid–water, butanol–2 *N* hydrochloric acid and acetic acid–hydrochloric acid–water respectively were: 0·24, 0·47; 0·69; 0·49; respectively. The R_F values reported for cyanidin in these solvents are: 0·24; 0·69; 0·50. Robinson's ferric chloride test was applied to extracts, in *iso*-amyl alcohol containing 1 per cent hydrochloric acid, of pear core tissue, after conversion to anthocyanidin by boiling with added acid. On addition of water, sodium acetate and a small amount of ferric chloride and shaking, the organic solvent layer turned blue just as cyanidin does. The anthocyanidin obtained from pear core and pear seed was stable to oxidation, as is cyanidin. The only anthocyanidin obtained from pear tissue thus is similar in R_F value and other properties to cyanidin.

M. A. Joslyn
Richard Peterson

Department of Food Technology,
University of California,
Berkeley 4, California.
May 2.

[1] Bate-Smith, E. C., in "Advances in Food Research", **5**, 262 (ed. E. M. Mrak and G. Stewart, Academic Press, 1954).
[2] Geissman, J. E., in "Modern Methods of Plant Analysis", **3**, 450 (ed. K. Paech and M. V. Tracey, Springer Verlag, Berlin, 1955).
[3] Knapp, A. W., and Hearne, J. F., *Analyst*, **64**, 475 (1939).
[4] King, F. E., and Bottomley, W., *J. Chem. Soc.*, 1399 (1954).
[5] Bate-Smith, E. C., and Lerner, N. M., *Biochem. J.*, **58**, 126 (1954).
[6] Joslyn, M. A., *Indust. Eng. Chem.*, **33**, 308 (1941).
[7] Kiesser, M. E., Pollard, A., and Williams, A. H., *Chem. and Indust.*, 1260 (1953).

Apparatus for Aeration and Sampling of Bacteria during Growth and Metabolic Studies

The need frequently arises for the sampling of bacterial cultures during aerated growth, or of non-proliferating bacterial suspensions in the course of metabolic studies under aerated conditions. Methods requiring the use of a pipette for the withdrawal of samples are somewhat unsatisfactory because the aeration arrangements, usually capillary tubing or tubing carrying a sintered glass distributor disk, are

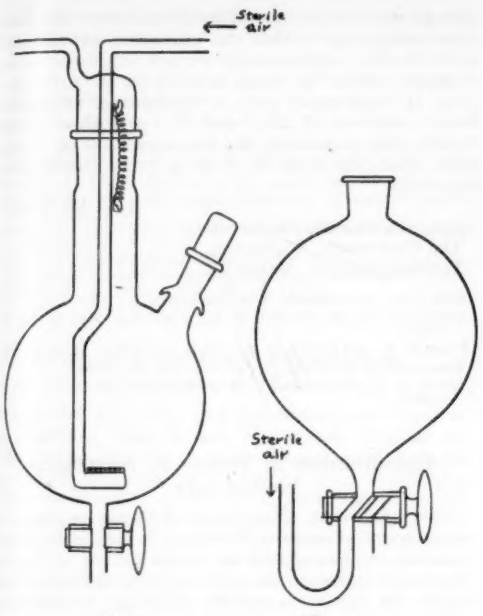


Fig. 1

disturbed when the pipette is introduced into the neck of the flask or tube. The present apparatus were designed to permit aeration and sampling of cultures with the minimum of operations.

Type 1. This apparatus is illustrated in Fig. 1*A*. A 1-litre round-bottom flask with *B*40 neck carries a special glass head with inlet and outlet arms. The inlet tube, which extends almost to the bottom of the flask, bears a sintered glass distributor disk of 20 mm. diameter and porosity No. 1. The head is held in position by two spring clips. At the bottom of the flask is fitted a wide-bore drain stopcock with a stem $\frac{1}{2}$ in. long which permits samples to be withdrawn as required. The combined effect of short stem and wide-bore is to prevent liquid from being retained in the stem. Additionally, the flask has a *B*19 socket set at an angle to the neck; this is used as an inoculation port or for the addition of substrates. The stopper may be replaced by a tube bent at an angle, so that it forms a side-arm similar to that of a Warburg manometer flask. Simply by rotating this tube in its socket the contents are discharged into the culture flask.

The apparatus is autoclaved in an assembled condition. A small folded strip of Kraft paper is inserted between the ground-glass joints to prevent possible seizure during the process. These joints are then covered over with Kraft paper. After sterilization, the strips of paper are removed with sterile forceps and the joints are then properly seated. The stopcock is lightly treated with silicone grease.

Type 2. With an organism that grows in clumps in liquid media, such as *Sarcina lutea*, even when using vigorous aeration in an apparatus of type 1, there was a tendency for cells to sediment and collect in the stopcock outlet below the glass disk distributor when growth extended over periods of 18–24 hr. To eliminate this difficulty the apparatus shown in Fig. 1*B* was devised. It consists of a 1-litre capacity pear-shaped dropping funnel with *B*24 neck. At the base is fitted a three-way double oblique bore stopcock with one vertical outlet $\frac{1}{2}$ in. long and the other U-shaped. The latter tube is used as the inlet for the sterile air stream which, entering from the base of the funnel, ensures thorough agitation of the medium. By turning the stopcock the air supply is momentarily cut off, a sample withdrawn through the vertical outlet, and aeration then resumed. The mouth of the funnel is closed by a cotton-wool plug. Where a compressed-air supply is not available, the requirements of this apparatus may be met by a small aquarium air pump.

If the air supply is replaced by nitrogen, both pieces of apparatus may be used for anaerobic studies where sedimentation is to be avoided. We have found type 1 to be very useful for organisms such as *Escherichia coli* and *Aerobacter aerogenes* while, as mentioned, type 2 was designed for use in our studies with *Sarcina lutea*.

The pieces of apparatus were made for us by Messrs. Quickfit and Quartz, Ltd., Stone, Staffordshire.

We are indebted to Mr. D. R. S. Cameron for his help and to the Medical Research Council for a grant-in-aid.

E. A. Dawes
W. H. Holms

Department of Biochemistry,
University of Glasgow.

Relation between the Optical and Thermodynamic Properties of Saturated Paraffinic Hydrocarbons

The optical properties of hydrocarbons, such as the refractive index and the magneto-optical rotating power, are controlled by absorption frequencies in the far ultra-violet region of the spectrum. These frequencies are due to electronic excitation of the molecules, and since the electrons involved are the outer, that is, the valency, electrons it is reasonable to anticipate a correlation between these electronic transitions and the strength of the valency bonds, that is, the thermodynamic properties of the compounds.

The ratio p/γ, where p is the number of dispersion electrons per molecule effective in optical refraction and γ is the magnetic anomaly, may be calculated from a knowledge of the refractive index (n), the magneto-optical rotating power (V) and the density (d) by the equation[1]:

$$\frac{p}{\gamma} = \frac{\pi}{2\lambda^2 eA} \cdot \frac{M}{d} \cdot \frac{(n^2-1)^2}{nV}$$

where λ is the wave-length of the light used, e is the electronic charge and A is the Avogadro number. This equation is valid provided the frequency of the light concerned is far from the frequency of the absorption band, and provided the optical dispersion can be regarded as being controlled by a single absorption frequency. Thus the expression is applicable to most saturated hydrocarbons when sodium D light is used. Darwin and Watson[2] have shown that for most hydrocarbons, γ is approximately 0·60 for the sodium D line. On this basis, values of p have been calculated for forty-two liquid paraffin hydrocarbons in the range C_5 to C_{20}, using values for n_D^{20}, V_D^{20} and d^{20} from the literature[3,4].

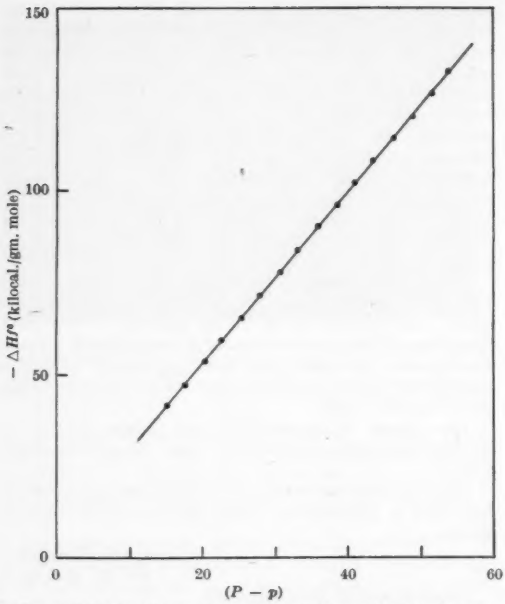


Fig. 1. Relation between standard heat of formation (ΔH_f^0) and number of inactive valency electrons ($P-p$) for *n*-paraffins

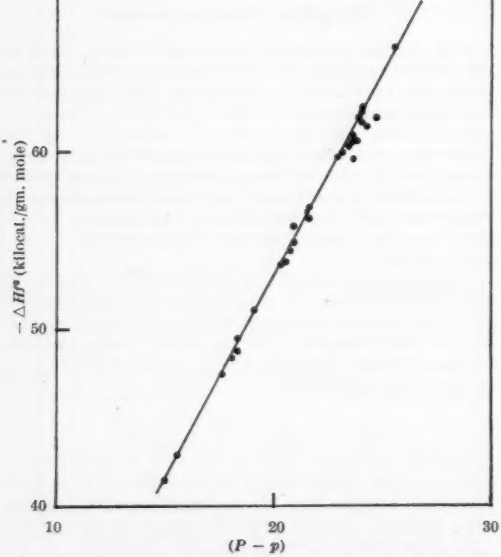


Fig. 2. Relation between standard heat of formation (ΔH_f^0) and number of inactive valency electrons ($P-p$) for pentane, hexane, heptane and octane isomers, and *n*-nonane

Figs. 1 and 2 show that the value of $(P-p)$, where P is the number of valency electrons per molecule, is a linear function of the standard heat of formation of the liquid (ΔH_f^0). The values of ΔH_f^0 used are those listed at 25° C.[5], since it is considered that the small error introduced through the use of the two different temperatures is relative only and does not seriously change the correlation. Deviations from the linear relationships are within the estimated experimental error of the measurements except for three octane isomers. While the linear relation for the *n*-paraffins (Fig. 1) could result from a combination of separate linear relations of ΔH_f^0 and $(P-p)$ with molecular weight, the correlation for the isomers (Fig. 2) suggests that the relation is of a more fundamental character.

C. W. Nutt

Dept. of Chemical Engineering,
The University, Edgbaston,
Birmingham 15. March 28.

[1] Nutt, C. W., and Labbauf, A. (in the press).
[2] Darwin, C. G., and Watson, W. H., *Proc. Roy. Soc.*, A, 114, 474 (1927).
[3] Foehr, E. G., and Fenske, H. R., *Indust. Eng. Chem.*, **41**, 1956 (1949).
[4] Waterman, H. J., *et al.*, *J. Inst. Pet.*, **36**, 281 (1950).
[5] Prosen, E. J., and Rossini, F. D., *J. Res. Nat. Bur. Stand.*, 34, 263 (1945).

Examination of Honey in Australian Honey-ants

The honey-ant (*Melophorus inflatus*) is found in many parts of central Australia, where it is highly regarded by the aborigines as an article of food[1,2]. The honey-bearing ants seem to be modified workers which are fed with nectar or honey by ordinary workers until their distended abdomens approach ⅜ in. in diameter[1]. "In eating them the native seizes each with the fingers by the forepart of the body and, after blowing off the dust, places the distended abdomen of the insect in the mouth and bites it off, letting the slightly acid honey flow over the tongue with evident satisfaction. The abdomen is swallowed while the remainder of the body is discarded"[3]. Colonies of these ants are generally found in rather arid country often near mulga trees. Little seems to be known of their habits, or of the origin of the honey, which is apparently stored against a barren season[4]. As a contribution to this problem, we have now examined the carbohydrate constituents of this honey.

Using a 5 per cent solution of the honey and 1 per cent solutions of glucose and fructose as controls, paper chromatographs were run in pyridine/water/ethyl acetate, and acetic acid/water/ethyl acetate. The application of aniline picrate to the chromatograms developed by both solvent systems gave a prominent spot corresponding to glucose and a less prominent spot corresponding to fructose. The presence of the latter was also confirmed by spraying the paper with urea oxalate. A very faint spot probably corresponding to a disaccharide (but not sucrose) was observed when a 25 per cent solution of the honey was spotted on the paper, which was then developed for fifty-five hours.

An estimation of the reducing sugars by the Lane and Eynon method gave 59 per cent. This result, together with the optical rotation, was used (Mathews formula) for determining the fructose : glucose ratio[5]. This was found to be 0·67. In bee-honey, fructose generally predominates, and this ratio averages 1·20; but wide variations are found, depending on the source of the honey. According to Wetherill[6], the Mexican honey-ant produces honey consisting of an almost pure solution of fructose, but the evidence presented is inconclusive.

We wish to thank Mr. M. J. Barrett, of the Department of Dentistry, who kindly collected some of these

honey-ants at the Yuendumu Native Settlement, about 190 miles north-west of Alice Springs.

G. M. Badger
W. Korytnyk

University of Adelaide,
South Australia. April 5.

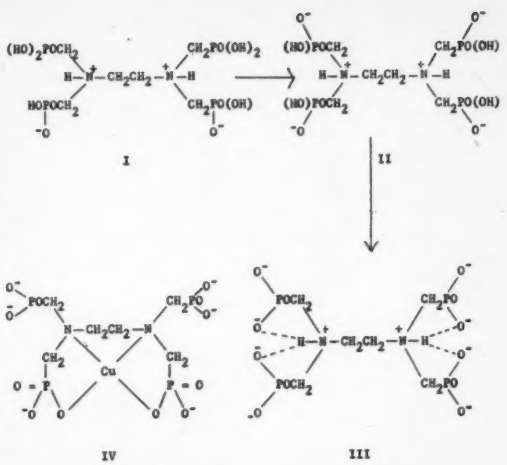
[1] Basedow, H., *Trans. Roy. Soc. South Austral.*, **28**, 12 (1904); "The Australian Aboriginal" (F. W. Preece and Sons, Adelaide, 1925).
[2] White, S. A., *Trans. Roy. Soc. South Austral.*, **39**, 707 (1915).
[3] McKeown, K. C., "Insect Wonders of Australia" (Angus and Robertson, Sydney, 1944).
[4] Spencer, B., and Gillen, F. J., "Across Australia" (Macmillan, London, 1912).
[5] Bates, F. J., and associates, "Polarimetry, Saccharimetry and the Sugars" (U.S. Government Printing Office, Washington, 1942).
[6] Wetherill, C., *J. Prakt. Chem.*, **58**, 430 (1853).

Ethylene-diamine-tetra(methylene-phosphonic) Acid

Since the publication by Schwarzenbach *et al.*[1] of the relatively high degree of calcium binding by N-methylene-phosphonic-imino-diacetic acid, it seems that the phosphonate group may be quite as effective as the carboxylate group in chelating agents. An attempt to prepare ethylene-diamine-tetra-methylene-phosphonic acid (EDPA) was therefore indicated because of its similarity to ethylene-diamine-tetra-acetic acid (EDTA). Although the preparation of this and similar compounds has been reported by Bersworth[2], the present communication gives quantitative information of the affinity of the ethylene-diamine-tetra-methylene-phosphonic acid anion for hydrogen ions and metal ions.

The procedure employed in the synthesis of ethylene-diamine-tetra-methylene-phosphonic acid was similar to the methods used by Schwarzenbach *et al.*[1] and Bersworth[2]. Ethylene-diamine was treated with sodium chloro-methylene-phosphonate in alkaline solution at reflux for three days. It was converted first to the lead salt with lead acetate and then to the free acid with hydrogen sulphide. The product was a colourless hygroscopic syrup which was very soluble in water, slightly soluble in alcohol and insoluble in ether. It was obtained as a glassy solid by dehydration under reduced pressure.

Potentiometric investigations of acid-base and metal-binding equilibria were carried out at 25° C. and 0·1 ionic strength with a Beckman Model *G* *p*H meter. The eight acid dissociation constants of the ligand were found to be 1·46, 2·72, 5·05, 6·18, 6·63, 7·43, 9·22 and 10·95. The equilibrium constants corresponding to the overlapping dissociation steps in each of the three buffer regions were determined by a graphical method. Because of the presence of two basic nitrogen atoms alpha to the acidic groups, the most acid form of the ligand is believed to be a double dipolar ion (I). If formula I is accepted, the presence of only two strongly acidic groups, corresponding to dissociation of hydrogen ions from neutral $-CH_2PO(OH)_2$ groups, becomes understandable. After the removal of two protons, there remain (formula II) four equivalent phosphonate hydroxyl groups which give rise to a long sloping buffer region involving four overlapping dissociation steps to form compound III. It is somewhat surprising that charge repulsion in III gives rise to a difference of only 1·7 *pK* units between the seventh and eighth dissociation constants. This may be due in part to the high negative charge of the anion, and to partial electrostatic binding of the ammonium hydrogens to the negative phosphonate oxygens.



The titration curves of the ligand in the presence of equimolar concentrations of metal ions given in Fig. 1 all indicate the formation of metal chelates containing as much as two hydrogen ions in addition to the metal. At higher *p*H all the acidic chelates go over to the 'normal' chelates from which all the dissociable hydrogens have been displaced. The copper (II) titration curve shows the sharpest break at eight moles of base per mole of ligand or metal, and indicates the formation of a metal chelate compound corresponding to formula IV. The titration curve of the iron (III) chelate compound shows partial hydrolysis of the normal chelate compound, indicating that at least one hydroxide ion becomes

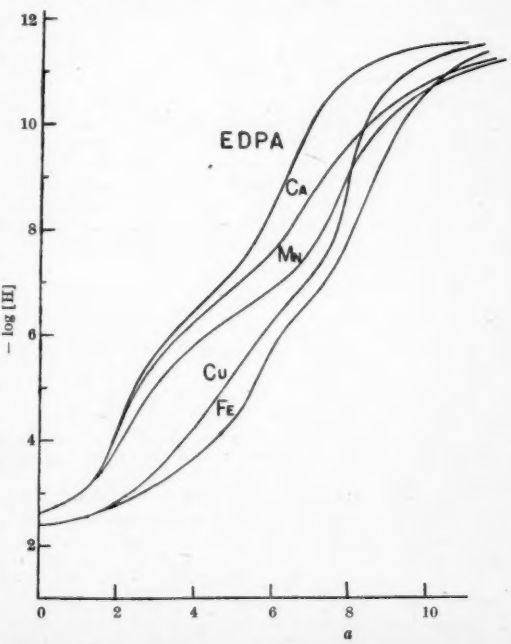
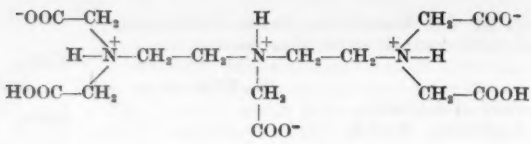
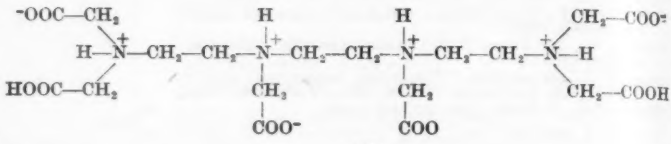


Fig. 1. Potentiometric titration of ethylene-diamine-tetra-methylene-phosphonic acid: $-\log [H]$ vs. *a*, moles of potassium hydroxide added per mole of ligand

bound to the metal at high *p*H in spite of the large negative charge on the chelate compound. The logarithms of the normal chelate stability constants for combination of the metal ion with the octa-negative anion were calculated as: calcium (II), 6·09; manganese (II), 9·75; copper (II), > 10; and iron (III), > 10. It is apparent from the relative positions of the copper (II) and iron (III) titration curves that the chelate of the latter metal is considerably more stable. The stability is sufficiently high that a solution of the light yellow iron (III) chelate may be stored at a *p*H of about 11 for a number of months without developing any sign of the precipitation of ferric hydroxide. The apparent stability of the iron (III) chelate compounds in alkaline solution indicates possible usefulness as an iron carrier.



(I)



(II)

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Sonya J. Westerback
Arthur E. Martell

Department of Chemistry,
Clark University. Feb. 17.

[1] Schwarzenbach, G., Ackermann, H., and Ruchstuhl, P., *Helv. Chim. Acta*, **32**, 1175 (1949).
[2] Bersworth, F. C., U.S. Pat. 2,599,807 (June 10, 1952).

Polyaminopolycarboxylic Acids derived from Polyethyleneamines

The effects of increasing length of the alkylene bridge on acid dissociation constants and metal chelate stability constants of homologues of ethylenediaminetetra-acetic acid derived from polymethylenediamines have been reported within recent years[1]. The effects of an increase in the polydentate and polyelectrolyte nature of polyaminopolycarboxylic acids derived from polyethylene polyamines have not been investigated except for a brief report on diethylenetriaminepenta-acetic acid[2]. An investigation of diethylenetriaminepenta-acetic acid and triethylenetetraminehexa-acetic acid was therefore undertaken because of their relationship to ethylenediaminetetra-acetic acid.

The acids were prepared by the reaction of diethylenetriamine and triethylenetetramine with sodium cyanide and formaldehyde under alkaline conditions according to the procedure of Bersworth[2]. The free acids were separated from the alkaline reaction products by means of the hydrogen form of 'Dowex-50' on a column process. Concentration of the eluate gave the acids as white crystals which were purified by recrystallization from a minimum volume of hot water.

The acid dissociation constants of diethylenetriaminepenta-acetic acid and triethylenetetraminehexa-acetic acid were determined from potentiometric data at 25° C. and 0·1 ionic strength (potassium nitrate) using a Beckman Model *G* *p*H meter. The equilibrium constants corresponding to the overlapping dissociation steps of the buffer regions were calculated by the graphical method of Schwarzenbach[4]. The acids are tri- and tetra-dipolar ions respectively having the formulæ:

Neutralization of the pentabasic diethylenetriaminepenta-acetic acid occurs with one strong inflexion corresponding to formation of the tripotassium salt. Triethylenetetraminehexa-acetic acid, a hexabasic acid, exhibits two inflexion points: a weak inflexion occurring on the addition of three equivalents of potassium hydroxide and a well-defined inflexion corresponding to the formation of the tetrapotassium salt.

The acid dissociation constants are listed in Table 1 together with the values reported by Kroll[3] for diethylenetriaminepenta-acetic acid.

Table 1. *pK* Values of the Apparent Ionization Constants of Diethylenetriaminepenta-acetic Acid and Triethylenetetraaminehexa-acetic Acid at 25° C. in 0·1 *M* Potassium Nitrate

Acid	pK_1	pK_2	pK_3	pK_4	pK_5	pK_6
DTPA	1·79	2·56	4·42	8·76	10·42	
DTPA*	1·90	2·70	4·42	10·62	12·59	
TTHA	—	2·64	4·08	6·26	9·67	10·82

* Determined at 25° C. in 0·1 *M* potassium chloride

It appears that triethylenetetraminehexa-acetic acid is almost completely ionized at the concentration used in this study (approximately 3×10^{-4} *M*). Each compound possesses two strongly acidic carboxyl groups (pK_1 and pK_2). The central ammonium groups are subject to the influence of the terminal positively charged ammonium groups. The net result of this configuration with its relatively high positive potential is an increase in acidity of the central ammonium groups as reflected in the values of pK_3 for diethylenetriaminepenta-acetic acid and pK_3 and pK_4 for triethylenetetraminehexa-acetic acid.

The behaviour of the acids with various polyvalent metal ions is now under examination. The increase in metal chelate stability constants and the ability to enter into bimetallic chelate formation arising from the increase in polydentate character indicate utilization of these compounds as metal carriers and metal buffers.

Albert E. Frost

Dow Chemical Co.,
Framingham, Mass.
April 16.

[1] Schwarzenbach, G., and Ackermann, H., *Helv. Chim. Acta*, **31**, 1029 (1948).
[2] Kroll, H., Pinching, G., and Butler, F., Abst. 122nd Amer. Chem. Soc. Meeting, Atlantic City, N.J., Sept. 14–19, 6*p* (1952).
[3] Bersworth, F. C., U.S. Patent 2,407,645 (Sept. 17, 1946).
[4] Schwarzenbach, G., Willi, H., and Bach, R. O., *Helv. Chim. Acta*, **30**, 1303 (1947).

Characterization of 17-Oxosteroids by Derivatives formed in the Zimmermann Reaction

DURING a study of 17-oxosteroid levels in blood plasma it was found that the amount of individual compounds available was frequently too small to permit determination and also identification by paper chromatography. After the determination of isolated 17-oxosteroids by Zimmermann reaction it is possible to recover these compounds as derivatives which can be used for characterizing the compounds measured.

The solution from the colorimeter cell was diluted with eight volumes of water and one volume of concentrated hydrochloric acid added. The acidified solution, which is colourless, was extracted with benzene ($3 \times \frac{1}{2}$ vol.) and the combined benzene extracts washed with water until neutral. When the Zimmermann reaction was repeated on the material extracted by benzene, the extinction corresponded to 60–95 per cent recovery of steroid; the colour appeared immediately with alkali alone and maximum intensity was obtained under Zimmermann conditions in 20 min.

When the recovered Zimmermann complexes of the separated 17-oxosteroids (approximately 5 μgm.) were chromatographed on No. 2 Whatman paper in a hydrocarbon/aqueous methanol system[1] spots could be located as dark areas by viewing in ultra-violet light of maximum intensity in the 240 mμ region (Hanovia *OX*7 filter). These areas were also revealed as purple spots by dipping in ethanolic potassium hydroxide (10 per cent w/v). The immediate appearance of the purple colour together with the absorption of ultra-violet light suggests that the *m*-dinitrobenzene is combined with the steroid on the paper chromatogram. These complexes appear to be very stable as they were not destroyed by hot acid hydrolysis (10 per cent hydrochloric acid v/v at 100° for 15 min.) or by the subsequent washing of benzene extracts by alkali.

Table 1, which gives the R_F values of the free 17-oxosteroids and of their derivatives when run in Bush partition systems, shows that whereas in the *A* system the free compounds run faster than their derivatives, in the B_1 system they run more slowly. This diverse behaviour appears to be associated with the partition system used and not with the C_{11}-oxygen function, for the 11-oxo-aetiocholanolone derivative runs in the *A* system more slowly than the corresponding free compound.

Table 1. R_F VALUES OF STEROIDS AND DERIVATIVES ON WHATMAN NO. 2 PAPER

(Equilibration time, 3 hr.; running time, 4 hr.; temperature, 37°)

	Free steroid	Derivative
Bush *A* system		
Dehydroisoandrosterone	0·32	0·23
isoAndrosterone	0·37	0·31
Aetiocholanolone	0·43	0·33
Androsterone	0·56	0·46
11-Oxo-aetiocholanolone	0·064	0·042
Modified Bush B_1 system		
11-Hydroxy-aetiocholanolone	0·40	0·70
11-Hydroxy-androsterone	0·50	0·78
11-Oxo-aetiocholanolone	0·64	0·83
11-Oxo-androsterone	0·70	0·88

Bush *A* system: 80–100° petroleum ether (10), methanol (8), water (2). Modified Bush B_1 system: 80–100° petroleum ether (5), benzene (5), methanol (7), water (3).
R_F values calculated against sudan IV, which was used for indicating the solvent front approximately.

The Zimmermann complexes formed from 5α-androst-3 : 17-dione, 5β-androst-3 : 17-dione, androst-4-ene-3 : 17-dione and androst-4-ene-3 : 11 : 17-trione did not move from the origin in Bush *A*, B_1 or B_5 systems.

This technique has enabled us to obtain further evidence of identity of steroids isolated from blood plasma by chromatography on alumina.

We wish to express our thanks to Dr. T. F. Gallagher, Sloan Kettering Institute, New York, and to Dr. W. Klyne, Hammersmith Postgraduate Medical School, for the gift of reference steroids, and to Sir Charles Dodds for his interest in this work.

A. E. KELLIE*
E. R. SMITH

Courtauld Institute of Biochemistry,
Middlesex Hospital Medical School,
London, W.1.
April 19.

* British Empire Cancer Campaign Fellow.

[1] Bush, I. E., *Biochem. J.*, **50**, 370 (1952).

An Asymmetric Catalyst

ASYMMETRIC synthesis has hitherto succeeded only by using reagents or solvents having the asymmetric configuration.

We have been able to synthesize optically active amines and amino-acids by using an asymmetric catalyst, based on the fact that the optical activity of the biological substances originates in the asymmetric structure of the enzyme proteins.

The asymmetric catalyst was obtained by reduction of protein–palladium complex which was prepared by adsorption of palladium chloride on silk fibroin fibre.

Optically active glutamic acid, phenylalanine and diphenylethylenediamine were formed by hydrogenating their precursors, diethyl α-acetoximinoglutarate, ethyl α-acetoximinophenyl-propionate, 4-benzilidene-2-methyloxazol-5-one and α-benzildioxime, respectively, in the presence of this catalyst.

Preparation of catalyst. 100 mgm. of palladium chloride was adsorbed on 300 mgm. of silk fibroin fibre, and the complex was reduced with hydrogen in 50 ml. methanol at 50° C., 80 kgm./cm.² for 1 hr.

Hydrogenation of diethyl α-acetoximinoglutarate. 10 gm. of diethyl α-acetoximinoglutarate was hydrogenated with the catalyst in 50 ml. methanol at 50° C., 80 kgm./cm.². The reaction mixture was filtered, evaporated *in vacuo*, hydrolysed for 1 hr., precipitated with hydrochloric acid, and extracted with acetone to remove organic acids. Then the product was recrystallized four times. Glutamic acid was obtained in a yield of 39 per cent. $[\alpha]_D^{15} = +2{\cdot}25°$ (*c.*, 7 per cent in 2*N* HCl). Analysis: calculated for $C_5H_{10}O_4NCl$: N, 7·63; found: N, 7·36. This compound was identified by paper chromatography and infra-red spectroscopy. The manometric analysis (by glutamic acid decarboxylase of *E. coli*) showed the same value of L(+) content.

Hydrogenation of ethyl-α-acetoximinophenyl-propionate. 6 gm. of ethyl-α-acetoximinophenyl-propionate was hydrogenated with the catalyst in 50 ml. methanol at 70° C., 90 kgm./cm.². The reaction mixture was filtered, evaporated *in vacuo*, hydro-

lysed for 4 hr. with 30 ml. 10 per cent hydrochloric acid and evaporated *in vacuo* again. The residue was dissolved in 10 ml. water, decolorized, evaporated to half volume of the solution *in vacuo*, diluted with 5 ml. methanol, and adjusted to *p*H 7·0 with aqueous ammonia. After standing overnight, 1·5 gm. of phenylalanine was obtained; m.p. 261·5° C. $[\alpha]_D^{15} = +9{\cdot}25°$ (*c.*, 9 per cent in water). Analysis: calculated for $C_9H_{11}O_2N$: N, 8·48; found, N, 8·23. This compound had the same R_F value as the standard phenylalanine.

Hydrogenation of 4-*benzylidene*-2-*methyloxazol*-5-*one.* 5 gm. of 4-benzylidene-2-methyloxazol-5-one was hydrogenated with the same catalyst in 50 ml. methanol at 75° C., 90 kgm./cm.². The reaction mixture was filtered, evaporated *in vacuo*, hydrolysed for 4 hr. with 30 ml. 10 per cent hydrochloric acid. The acid solution was extracted with ether, and the water layer was evaporated *in vacuo*. The residue was dissolved in 10 ml. water, decolorized, concentrated to 3 ml., diluted with 3 ml. methanol, adjusted to *p*H 7 with aqueous ammonia. After standing overnight, 0·7 gm. of phenylalanine was obtained; m.p. 280° C. $[\alpha]_D^{20} = +12{\cdot}5$ (*c.*, 9 per cent in water). Analysis: calculated for $C_9H_{11}O_2N$: N, 8·48; found, N, 8·23. This compound was identified by paper chromatography.

Hydrogenation of α-*benzildioxime.* 5 gm. of α-benzildioxime was hydrogenated in 10 per cent ammoniacal methanol at 80° C., 80 kgm./cm.², with the same catalyst, and the product was recrystallized from *n*-butanol. Diphenylethylenediamine (2·5 gm.) was obtained. Analysis: calculated for $C_{14}H_{16}N_2$: C, 79·21; H, 7·60; N, 13·20; found: C, 78·05; H, 7·20; N, 12·12. $[\alpha]_D^{15} = +8{\cdot}75$ (800 mgm./100 ml. of ether); $[\alpha]_D^{15} = +431{\cdot}0$ (29·6 mgm./100 ml. of ether). (In this experiment, we observed the wide variation of $[\alpha]_D$ of diphenylethylenediamine with the concentration of the substance in diethyl-ether.)

It appeared that the palladium adsorbed on the supporter having the asymmetric configuration was capable of catalysing the asymmetric reduction.

S. Akabori
S. Sakurai
Y. Izumi
Y. Fujii

Faculty of Science,
Osaka University,
Osaka.
March 8.

A New Reagent for the Determination of Thorium

Several organic acids[1-4] have been used for the quantitative precipitation of thorium. By a careful control of the *p*H value, thorium may be separated from the rare earths. The precipitate in most cases is rather of indefinite composition, and for a quantitative determination, it has to be ignited to thorium oxide and weighed. We have been engaged in investigating derivatives of cinnamic acid to see if they possess any advantages over other acids which have been employed hitherto.

It was found that *m*-nitro cinnamic acid not only gives a clear-cut separation of thorium from other trivalent rare-earth ions, but also gives a thorium precipitate of definite composition. The precipitated thorium salt is the tetra-*m*-nitro cinnamate and is one of the very few examples of precipitation of thorium as the tetravalent salt.

An alcoholic solution of *m*-nitro cinnamic acid was added to a solution of thorium salt at *p*H 2·0 or less and this was carefully adjusted to 3·8–4. The higher *p*H value is specially necessary when sulphate ions are present. Thorium came down as a granular precipitate. The precipitate was filtered, washed with hot alcohol and weighed as thorium tetra-*m*-nitro cinnamate. It was then ignited and weighed as thorium oxide. The following are typical results.

Weight of thorium tetra-*m*-nitro cinnamate (gm.)	0·1135
Weight of ThO_2 (by calculation) (gm.)	0·02997
Weight of ThO_2 (by ignition) (gm.)	0·0299

Thorium may therefore be determined by a direct weighing of the precipitate instead of by igniting, as has been done hitherto.

The same experimental procedure may be followed for separation of thorium from trivalent rare earths; if, however, the proportion of the rare earths is preponderantly high, a double precipitation may be followed.

Tetravalent ions like titanium, zirconium, cerium (ic), etc., are also precipitated by this reagent and would thus interfere.

Further details will be published elsewhere.

M. R. Verma
K. C. Agrawal
S. D. Paul

National Physical Laboratory of India,
Hillside Road,
New Delhi.
April 28.

[1] Moeller, T., Schweitzer, G. K., and Starr, D. D., *Chem. Rev.*, **42**, 63 (1948).
[2] Raghava Rao, Bh. S., *et al.*, several papers, cf. *J. Ind. Chem. Soc.*, *J.S.I.R.*, *Anal. Chem. Acta*, etc. (1946–55). Banks, C. V., and Byrd, C. H., *Anal. Chem.*, **25**, 416 (1953).
[3] Osborn, G. H., *Analyst*, **73**, 381 (1948). See also, "B.D.H. Book of Organic Reagents", 119 (London, 1946).
[4] Datta, S. K., and Banerjee, G., *Anal. Chim. Acta*, **12**, 23, 38 (1955).

Recording Differential Thermogravimetric Balances

In recent years, interest has been revived in the application of the thermogravimetric technique for the characterization of inorganic and organic compounds, and for studies concerning their thermal decomposition process. Several types of automatic balances have been developed—some of them now being commercially available—to give recorded curves of the cumulative weight-loss, with time or temperature, of a sample decomposing thermally under controlled conditions. It is often necessary to prepare, from this record, a curve of the rate of weight-loss as a function of time or temperature, by the somewhat tedious and relatively inaccurate process of graphical differentiation.

In order to assist our investigations on the thermal decomposition process of coal and related compounds, two types of thermogravimetric balances were devised to give automatically precise and continuous records of the differential weight-loss, together with

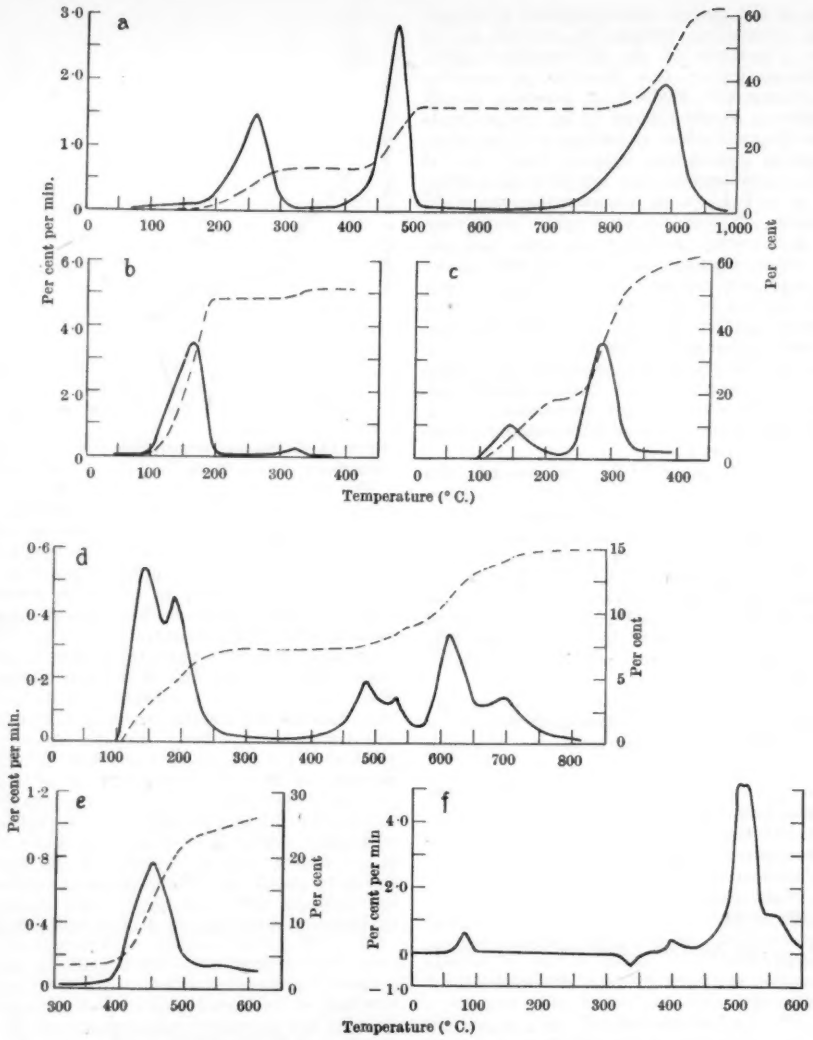

Fig. 1. Examples of differential thermogravimetric curves obtained with prototype balance. ———, Differential thermogravimetric curve; – – – –, cumulative weight-loss curve. (a) Calcium oxalate, monohydrate; heating-rate, 6 deg. C./min. (b) Dibasic sodium phosphate heptahydrate; heating-rate, 3 deg./min. (c) Starch, heating-rate, 3 deg./min. (d) Shale from Victoria Tunnel coal seam, N.S.W.; heating-rate, 3 deg./min. (e) Coal sample, Victoria Tunnel seam; heating-rate, 3 deg./min. (f) Coal sample, Victoria Tunnel seam; heated in air at 3 deg./min.

the usual cumulative weight-loss. These balances, briefly described herewith, differ in principle from the differential thermogravimetric balances already described by De Keyser[1], and Erdey *et al.*[2]. So far as I am aware, these are the only apparatuses of this kind which have been reported.

In the present apparatus, the balance system is maintained in a state of continuous equilibrium by means of a counterbalancing force, applied at the necessary rate, proportionally controlled by an electromotive force equivalent to the rate of loss in weight. It is virtually a null-point balancing system with regard to the rate of weight-loss. The methods of electro-mechanical linkage, however, differ in the two types.

In one design of balance, which has a torsion wire in its construction, the restoring couple necessary to maintain the beam at a certain point of balance was achieved by a special type of servo-motor rotating the torsion head. In the other type, an analytical balance was adapted in such a way that the sample was counterbalanced by the suspended electrode of a silver coulometer, arranged so as to minimize surface-tension effects: as the sample changed in weight, balance was maintained by a corresponding change in weight of the silver electrode due to a control current passing through the cell. The necessary voltage and current controls, in both these types of balances, were effected by a photocell movement detector, and magnetic amplifier with an output rectifier. An

'ohmic drop' in the output circuit enabled a proportion of the controlling voltage or current to be recorded as a measure of the differential weight-change. Integration of this function by electro-mechanical means also enabled an accurate record of the cumulative weight-change to be made simultaneously on the multi-point potentiometric recorder.

The prototype torsion-wire balance, which is now in continual routine service, can record total weight-changes of up to 0·5 gm. at a maximum rate of 30 mgm. a minute; the cumulative weight-change may be read to an accuracy within 1 per cent, and the differential weight-change may be determined to within 0·2 mgm. per minute. The differential pyrolysis curves obtained by this instrument are of value in the characterization of coal by rank, and for studies of their mechanism of thermal decomposition. These curves are also particularly useful for providing information of a complementary nature which may be correlated with other thermal properties of coal measured by such techniques as differential thermal analysis and plastometry.

Although originally designed for coal research, the apparatus should also find useful application in other fields of work such as inorganic and organic analyses, mineralogy, adsorption studies and the analysis of the particle-size distribution of powders by sedimentation. Some examples of the decomposition of certain inorganic and organic substances under linear heating-rates are illustrated in Fig. 1. The apparatus and its application to studies of the thermal behaviour of coal and related compounds will be described in detail elsewhere.

The work described here was carried out as part of the programme of the Coal Research Section of the Commonwealth Scientific and Industrial Research Organization, Australia.

P. L. Waters

Coal Research Section,
Commonwealth Scientific and
Industrial Research Organization,
P.O. Box 3,
Chatswood, New South Wales.
March 22.

[1] De Keyser, W. L., *Bull. Soc. Franc. Céram.*, **20**, 2 (1953); *Nature*, **172**, 364 (1953).
[2] Erdey, L., Paulik, F., and Paulik, J., *Nature*, **174**, 885 (1954).

Evidence for Substructure in Single Crystals of Potassium Chloride

Measurements of the optical scattering and polarization of the ionic current in single crystals of potassium chloride have recently been made.

The variation of the intensity of the scattered light with the angle of scatter was measured for monochromatic ultra-violet ($\lambda = 3650$ A.). The crystal was suspended in benzene, which has a refractive index very close to that of potassium chloride ($n = 1{\cdot}55$). The scattered light intensity was measured with a sensitive photo-electric apparatus using a lock-in detector based on the 100 c./s. modulation of the mains-operated mercury arc light source. The curves in Figs. 1 and 2 show the difference of the intensities of the light scattered from the crystal immersed in the liquid and from the liquid alone. Curve I (Fig. 1) shows the angular distribution of the light scattered from a single crystal of potassium chloride cooled slowly after growth from the melt, and

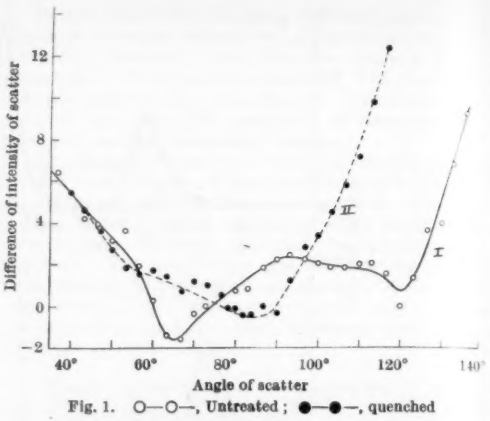

Fig. 1. ○—○—, Untreated; ●—●—, quenched

curve II shows the results for the same crystal after quenching in air from 700° C. to room temperature.

The deviations from a simple Rayleigh scattering curve indicate the presence of internal scattering structures of fairly uniform dimensions of the order of the wave-length of the light. The results are similar to those obtained by Humphrey-Owen[1] for the variation of the scattering at 90° with wave-length in single crystals of sodium chloride and suggest a comparison with Mie's scattering theory. This applies to isolated spherical particles (radius r) of refractive index differing from that of the surrounding medium. The theory predicts a scattering curve having one or more minima the angular positions of which depend on the parameter $\alpha = 2\pi r/\lambda$. Typical curves for $n = 1{\cdot}5$ plotted from the tables compiled by the National Bureau of Standards[2] are shown in Fig. 2. The position of the minimum in the experimental scattering curve I of Fig. 1 for the normal crystal corresponds to a value α of about 1·1 and hence to a diameter of about 1300 A. for the equivalent scattering spheres. Curve II shows that the dimensions of the scatterers are reduced by quenching; the position of the minimum and the ratio of the light intensities scattered

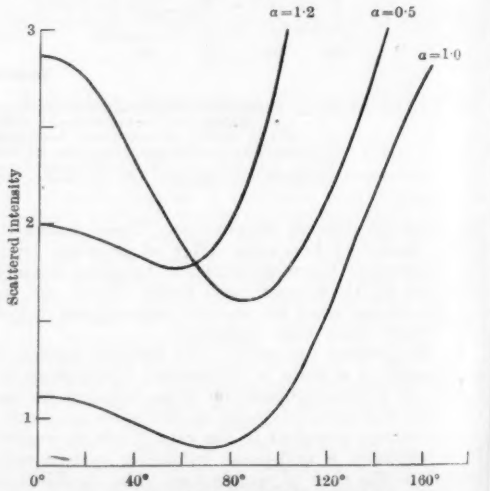

Fig. 2

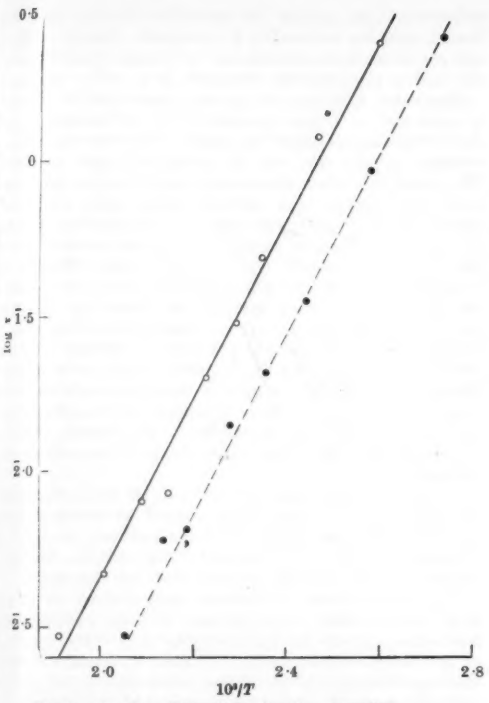

Fig. 3. O—O—, Untreated; ●—●—, quenched

in the forward and backward directions indicate that α lies between 0·5 and 0·8 and thus $2r$ between 600 and 900 A.

The electrical measurements were carried out in connexion with investigations on the ionic conduction of single crystals of a number of alkali halides over the temperature-range 20°–300° C. The d.c. method used in these investigations, essentially as described by Cunnell and Schneider[3], allows ionic polarization effects to be observed in detail. Such effects were found in all alkali halides investigated and were established to be intrinsic and not electrode or surface effects. In its simplest form, polarization is observed as a decay of the ionic current, following the application of a constant potential ('step'), from a high initial value to a lower steady value. The rate of decay described quantitatively by a polarization time τ, the time of decay to a current-value halfway between initial and final currents, depends on the temperature of the applied potential and the thermal and mechanical history of the specimen. The temperature dependence follows $\tau = \tau_0 \exp(-u/kT)$ with an activation energy u near the migration energy of positive ion vacancies.

Measurements with specimens cleaved from the same single crystal of potassium chloride as the sample used in the scattering experiments have shown that the polarization time is markedly decreased by quenching, while over a wide temperature-range both the initial and final values of the ionic conductivity are unaffected. Fig. 3 is a plot of $\log \tau$ *vs* $1/T$ for a potassium chloride crystal before and after quenching in air from 700° C.

Polarization may be explained as a blocking of the ionic current by internal boundaries. According to Jaffe's theory[5] of the rate of build-up of space charge involved in such blocking phenomena, the polarization time should be proportional to the square of the distance between the boundaries. The ratio of the observed polarization times in the untreated and quenched crystals is 2·24, which would indicate that the average distance between the blocking boundaries is decreased by quenching by a factor of 1·5. On the assumption that Jaffe's theory is applicable in detail, together with the accepted value for the diffusion coefficient of positive ion vacancies, the actual value of the distance between blocking boundaries is estimated to be of the order of 2000 A.

The fact that both the distance between internal boundaries which determines the polarization of the ionic current, and the dimensions of the structure giving optical scattering in potassium chloride, are reduced in about the same ratio by quenching, suggests that the same internal structure is responsible for both effects.

N. S. Parker
E. E. Schneider

Physics Department,
King's College,
University of Durham,
Newcastle upon Tyne 1.
April 5.

[1] Humphrey-Owen, S. P. F., *Proc. Phys. Soc.*, B, **68**, 325 (1955).
[2] U.S. National Bureau of Standards, Applied Maths. Series 4 (Jan. 1949).
[3] Cunnell, F. A., and Schneider, E. E., *Proc. Phys. Soc.* (In the press).
[4] Brennecke, C. G., *J. App. Phys.*, **11**, 202 (1940).
[5] Jaffe, G., *Ann. Physik*, **16**, 217, 249 (1933).

The Minimum of Melting Point in Homologous Series

Last year, in a letter in *Nature*[1], Foster and Hammick pointed out the similarities of the curves of the melting points against the length of the hydrocarbon chain, with a minimum in C_8, for both the alkylanilines and alkylnaphthols. They seem not to be aware of similar comments made previously, notably by Lee[2]. Lee suggests that this characteristic results from a helicoidal structure of long hydrocarbon chains which, as in the tension theory of Baeyer on carbon rings, would have a periodicity of 5 carbon atoms.

Against this hypothesis there are the following objections: (*a*) The anomalies for the C_8 term ought to be observed for other properties also, and to be recurrent for the terms in C_{10}, C_{15} and so on, which is not the case. (*b*) In my book "Les Constantes Physiques des Composés Organiques Cristallisés" (Masson, Paris, 1953), pp. 270–304, are quoted some hundreds of series, with the necessary data, and it is shown that the minimum of melting point may equally well be at any term from C_1 to C_{12}. (*c*) Radiograms of long-chain organic compounds show that, in the crystalline state, their molecules may be considered as long rods without any helicoidal structure.

My interpretation of these facts is as follows: in long-chain derivatives the functional radical is of secondary importance only, and has a rather small influence on the melting point; all these series have parallel melting point curves, which converge to a common limit of about 120° C.; only the hydroxyl and amino derivatives have much higher melting points, resulting from hydrogen links, but converge to the same temperature limit. For the first term of a homologous series, on the contrary, the melting point is essentially fixed by composition, functional

structure and stereochemical configuration; when a hydrogen atom is replaced by a short hydrocarbon chain, the symmetry of the molecule diminishes and the melting point falls progressively until the falling curve cuts the rising curve of the higher terms of the series. Therefore the position of the minimum is determined by the weight of the functional radical; the heavier the radical the higher in the series is the minimum, as with the α-brom-β-naphthylamides and the alkyl-iodides of mercury, where it is as far as C_{12}.

J. Timmermans

Physicochemical Laboratory,
University of Brussels.

[1] *Nature*, **175**, 275 (1955).
[2] Lee, W. B., *Trans. Farad. Soc.*, **23**, 634 (1927); *Nature*, **120**, 48 (1927).

Evaporation from an Electric Arc in Vacuum

For some time, workers producing thin films *in vacuo* have questioned whether an electric arc could be used for evaporating metal films. The method is a possible solution to the problem of evaporating metals of low vapour pressure such as platinum, which cannot be easily evaporated from the commonly used metal filaments because they dissolve the support. Further, if both electrodes are of the metal to be deposited, the film will not be contaminated by other metals as occurs when a refractory metal heater is used.

It is therefore of interest to read the recent claim by Hiesinger[1] that metals can be evaporated ". . . in an arrangement whereby an electric spark is generated between electrodes which consist of the material which is to be deposited in a high vacuum", and, further, "The method can be used with advantage in the form where the ions produced by the electric spark are accelerated by an electric field, so that the energy of atomic impact on the substrate is increased beyond the normally available thermal energy".

Since this was published, Vodar *et al.*[2] have described an apparatus in which the arc was operated intermittently by vibrating the electrodes, using a relay coil. These workers found that the metal atoms were emitted from the cathode (although this was at the lower temperature) and were mainly negatively charged. When the receiver was a conductor and made positive with respect to the cathode "almost the whole of the deposited metal was concentrated on the support under tension".

Recently, I discovered an early patent by Edison[3] on a "Process of Duplicating Phonograms" from which the following is quoted: "The phonogram so impressed with the phonographic record is placed in a high vacuum, in which an electric arc, continuous or discontinuous, is produced between electrodes of metal or in which metal vapour is otherwise produced. The electric arc produces a vapour of the metal of which the electrodes are composed, which vapour is deposited on the indented surface of the phonogram".

It is doubtful if Edison's electric arc was operated at the pressure now generally understood as 'high vacuum', that is, 0·1 micron mercury or less (Vodar *et al.* operated their arc at 0·01 micron mercury), because apart from other factors the pumping apparatus was not sufficiently developed.

It would be useful to know the type of apparatus Edison used, because it is often difficult to operate continuously an arc in high vacuum; after the arc is struck the supply of metallic vapour may be insufficient for ionization to maintain the arc. Thus the use of an intermittent arc by Vodar *et al.* whereby the arc is periodically re-struck is a novel solution.

The same difficulty is not experienced when an arc is operated at higher pressures (> 10 microns mercury) because a supply of positive ions for the maintenance of the arc can be obtained from the gas. The discharge then occurs in mixed vapour and gas, and both anode and cathode can reach sufficient temperature to evaporate rapidly. Rossin[4] states that in the arc melting of metals the vapour emitted from the molten anode is the conductor and that it is confined in the arc by the gas molecules at a pressure of 10 mm. mercury; but at 10μ mercury the arc becomes unstable due to free evaporation of the metal. Evaporation may take place from a cathode during cathodic sputtering at high current densities in a glow discharge. Thus both zinc and cadmium cathodes will evaporate rapidly if their temperature is allowed to rise during cathodic sputtering. The metal vapour is ionized and the glow may change to an arc if the current is not limited.

It appears that there are at least three mechanisms by which vapour can be produced in electric arcs, namely: (1) sputtering from the cathode under ion bombardment; (2) thermal evaporation of the cathode; (3) thermal evaporation of the anode.

The recent work of Germer and Boyle[5] on short-field emission arcs indicates that thermal evaporation from the cathode electrode may be due to the melting of surface prominences by the field emission currents flowing through them. Thus the evaporation of the cathode electrode noted by Vodar *et al.* may not have been due to ion bombardment as they assumed. A further study of the electric arc *in vacuo* would be of value in view of its potential use as a vapour source for film deposition.

L. Holland

Edwards High Vacuum, Ltd.,
Crawley, Sussex. April 24.

[1] Hiesinger, L., German Patent No. 915765, July 29, 1954.
[2] Vodar, B., Minn, S., and Offret, S., *J. Phys. Rad.*, **16**, 811 (1955).
[3] Edison, T. A., U.S. Patent No. 484,582, Oct. 18, 1892 (filed Jan. 30, 1888).
[4] Rossin, P. C., *Gen. Elect. Res. Rep.*, 55-*RL*-1260 (1955).
[5] Germer, L. H., and Boyle, W. S., *J. App. Phys.*, **27**, 32 (1956).

A Simple Method of producing Visible Patterns of Tape-recorded Sounds

While visiting our laboratory, R.-G. Busnel of France directed our attention to a brief note by Pasquinelly[1] on making visible the magnetically oriented areas on tape recordings by immersing the tape in a viscous liquid suspension of ferromagnetic powder and draining off the excess. We have found a modification of this method useful for studying sounds of animals recorded on magnetic tape. Immersion proved unsuitable, because it did not produce clear patterns, and the recorded tapes were difficult to clean afterward.

Dry carbonyl iron powder (General Aniline and Film Corp., Types *E* and *SF*), however, produces good images of tape-recorded sounds, and we propose the name 'ferrograms' for these visible patterns. The recorded surface of the tape is drawn through a thin layer of the powder spread on smooth paper and the excess powder blown or snapped off. The powder is held on the tape at the regions of uniform magnetic orientation, forming images of the recorded sounds.

The spacing of bands on the tape is related to the frequency and temporal distribution of the sound and sound pulses and the density of deposit to the intensity. We have used this successfully with four brands of recording tape, although the results are better with some than with others.

These images are either photographed or removed from the tape by applying to it the sticky surface of a strip of adhesive transparent tape ('Texcel' or 'Scotch'). The adhesive tape is fastened on white paper or transparent cellulose film for permanent storage and detailed study. When mounted on a transparent material, the ferrograms can be made directly into lantern slides. The adhesive tape should be relatively new and unheated, otherwise damage to the recording tape may result, and it is well to press the adhesive surface as gently as possible on to the recording tape. After the pattern has been copied or removed, the recording tape is wiped free of powder and seems to be unaffected.

Fig. 1 shows some ferrograms thus produced. The use of this method to study the 'song', a series of short noise pulses, of a grasshopper, *Neoconocephalus ensiger*, is illustrated. Knowing the tape speed, it is easy to measure directly the duration of the chirps in this 'song', even though these are only 0·02–0·1 sec. in length. With magnification, the number, duration and spacing of the pulses in the individual chirps and other details can be studied. Comparison of the ferrograms with the oscillograms produced by the usual methods shows that they give good representations of the duration of the chirps and pulses composing the chirps and their relative intensities. The remaining ferrograms in Fig. 1 illustrate patterns produced by other sounds. The sound of the tuning fork, in contrast with the others, is relatively simple, and the pattern can be used for determining the frequency as well.

The recording-level must be relatively high for development of the patterns. There is a threshold-level below which no adhesion of the powder occurs. The method seems particularly suitable for noise pulses, such as the stridulatory sounds of many insects, where the instantaneous intensity of the individual pulse may be very high, although the average intensity is not, and where the chief interest lies not in analysis of frequency and intensity but in the distribution and duration of the sound pulses.

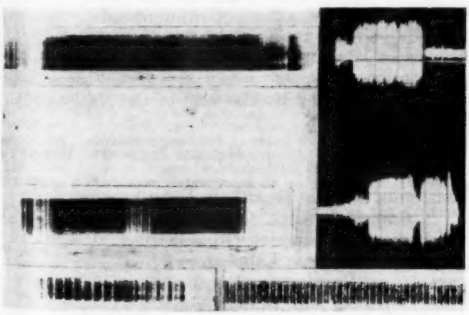

Fig. 1. Top and middle rows, ferrograms (left) and corresponding oscillograms (right) of chirps of *Neoconocephalus ensiger* at 18° C., recorded at 15 in./sec. tape speed; the duration of the chirps is about 1/10 sec. The upper record is the usual type for this species; the middle one is unusual in having a break in the main sound sequence. Bottom left, human voice saying syllable '*Ba*' recorded at 7½ in./sec. Bottom right, tuning fork (256 c./s.), recorded at 7½ in./sec. (All × 1½)

This method for the production of visible patterns of sounds is simple, direct, and uses no expensive equipment. Studies of the temporal characteristics, at least, of sounds can thus be made easily and cheaply by anyone who has a tape recorder.

This work was supported in part by Research Grant No. *E*-802 from the National Microbiological Institute of the National Institutes of Health, U.S. Public Health Service. We wish to thank Dr. Ackerman of this University and the General Aniline and Film Corporation for supplying the carbonyl iron powder, and Dr. Smyth of this Department for assistance in making the oscillograms.

HUBERT FRINGS
MABLE FRINGS

Department of Zoology and Entomology,
Pennsylvania State University,
University Park, Pa.

[1] Pasquinelly, F., in "L'Acoustique des Orthoptères", 50 (ed., R.-G. Busnel, Inst. Nat. Rech. Agron., Paris, 1955).

Combinatory Notation

CURRENT notation used in combinatory formulæ is by no means uniform, sometimes clumsy, as in $\binom{n}{r}$, and sometimes misleading in a factual sense as is ${}^nC_r$ or ${}^nCr = {}^nP_{r,n-r}$. I have elsewhere pointed out advantages of using $n^{[r]} = n(n+1) \ldots (n+r-1)$ by analogy with $n^{(r)} = n(n-1) \ldots (n-r+1)$ and $n_{[r]} = n^{[r]} \div r\,!$ in conformity with Aitken's usage $n_{(r)} = n^{(r)} \div r\,!$. In this notation $r_{[d]} = F_{r,d}$ specifies the entire family of Pythagorean figurates defined by $F_{1,d} = 1 = F_{r,0}$ and $F_{r,d} = F_{(r-1),d} + F_{r,(d-1)}$, just as $r_{(d)}$ specifies the term of the rth column and dth row of the derivative Pascal triangle. In combinatory terms, we may write for the number of different r-fold samples from a set of n distinguishable objects :

	Without restriction on repetition	With no repetition
Permutations	n_r	$n_{(r)}$
Combinations	$n_{[r]}$	$n_{(r)}$
Sum of combinations (from $r = 0$ to $r = n$)	$(n+1)_{[n]} = \dfrac{(2n)\,!}{(n\,!)^2}$	2^n

The multinomial theorem is valid for $\rho = r$, (r) or $[r]$ in the form $(A + B + C \ldots)\rho$, and the combinatory interpretation of the general term becomes more explicit if we write $n_r = n^r \div r\,!$ by analogy with $n_{(r)}$ and $n_{[r]}$ defined as above. We may then write the general term of the following expansions as on the right below :

$(A + B + C \ldots)^r$	$r\,!\, A_u \,.\, B_v \,.\, C_w \ldots$
$(A + B + C \ldots)^{(r)}$	$r\,!\, A_{(u)} \,.\, B_{(v)} \,.\, C_{(w)} \ldots$
$(A + B + C \ldots)^{[r]}$	$A_{[u]} \,.\, B_{[v]} \,.\, C_{[w]} \ldots$
$(A + B + C \ldots)_{(r)}$	$A_{(u)} \,.\, B_{(v)} \,.\, C_{(w)} \ldots$

By specifying the number of r-fold samples containing u of sub-set A, v of sub-set B, w of sub-set C, etc., of an n-fold set $(n = A + B + C \ldots)$, the following table then subsumes in an economical notation all the more familiar formulæ of linear combination and arrangements, including the two forms of what MacMahon calls the "Master Theorem".

	With no restriction on repetition	With no repetition
Permutations	$r\,!\, A_u.B_v.C_w \ldots$	$r\,!\, A_{(u)}B_{(v)}C_{(w)}$
Combinations	$A_{[u]}B_{[v]}C_{[w]} \ldots$	$A_{(u)}B_{(v)}C_{(w)}$

LANCELOT HOGBEN

University of Birmingham.
June 1.

Selection for Fibre Number in Merino Sheep

Carter[1] has reviewed work on the hair follicle group in sheep. This review emphasizes breed differences in the ratio of secondary to primary follicles, but does not mention any previous work on selection within a breed. Some preliminary results of a selection experiment are therefore presented, in which changes in both primary and secondary follicle counts per unit skin area have been demonstrated.

One section of a flock of medium-wool Australian merinos at the National Field Station, Cunnamulla, Queensland, consists of pairs of families, in which selection is for a high or low value of a single character. In one pair the character under selection is fibre number per unit area of taut skin (N), measured by the technique described by Turner *et al.*[2], which does not differentiate fibres from primary and secondary follicles. The groups were founded with animals drawn from one flock, chosen as being of average body-size, but ewes for the high group (HN) being required to have a fibre number above the mean plus one standard deviation, and those for the low group (LN), a fibre number below the mean minus one standard deviation. The foundation rams were chosen from the same flock as the ewes, the most extreme available being selected. Recruitment is from within each family, selection being made at 15–16 months of age.

Although follicle counts have not been required in selection, a skin sample has been taken from the centre of each clipped area immediately after removal of the wool sample. Counts per mm.^{2} of primary (P) and secondary (S) follicles have been made and the ratio S/P (R) calculated, using the techniques described by Carter and Dowling[3].

The mean fibre number for unselected progeny of the HN group each year has been consistently above the mean for those of the LN group. Of great interest is the fact that differences in both P and S contribute to the differences in N, the HN progeny having higher mean counts than the LN progeny for both types of follicle. Over the three sets of progeny now available, the weighted mean differences are $0{\cdot}50 \pm 0{\cdot}13$ for P and $19{\cdot}1 \pm 3{\cdot}3$ for S, both being significant at the 0·1 per cent level. The weighted mean difference in R is $3{\cdot}2 \pm 1{\cdot}1$ (significant at the 1 per cent level), the HN progeny again having a higher value than the LN.

The classic picture of the follicle population in the sheep is one of a series of groups, each containing a trio of primary follicles, with associated secondaries. If it is assumed that the number of primaries in a group remains unchanged, then changes in P indicate changes in the number of groups, while changes in R indicate changes in group-size. The two sources of change may possibly differ in their effect on the amount of wool produced per unit area of skin, and the relative importance of each is not yet known. Further investigations on this point are in progress.

Observed changes in S and P can be separated into those arising from the purely mechanical effect of changes in surface area, in which the total follicle number on the sheep is not altered, and those arising from environmental and genetic influences on the follicles themselves, in which the follicle number is altered. The purely mechanical effects have been eliminated in the present data by adjusting counts for difference in body-weight, taking surface area as approximately proportional to (body-weight)$^{2/3}$. It has sometimes been suggested that R should be used as an indicator of follicle or fibre population, because it is independent of mechanical changes due to variation in surface area. Since the present results have shown that P, S and R can all be influenced by selection, increases in R will not necessarily indicate increases in $(S + P)$, as can be shown by the following discussion.

If we denote changes in P by δP, in S by δS and in R by δR, then we have :

$$R + \delta R = \frac{S + \delta S}{P + \delta P}$$

$$= R\left(1 + \frac{\delta S}{S} - \frac{\delta P}{P} - \frac{\delta S.\delta P}{S.P} + \frac{(\delta P)^2}{P^2} + \cdots\right)$$

Changes in R will thus depend on the relative size of $\frac{\delta S}{S}$ and $\frac{\delta P}{P}$, and the following will hold :

(1) If $\delta P = 0$, R will change with δS, and will be an indicator of $(P + S)$.

(2) If $\left|\frac{\delta S}{S}\right| = \left|\frac{\delta P}{P}\right|$, both being of the same sign, R will be constant, irrespective of changes in $(P + S)$. Proportional changes in S and P could arise from the mechanical effect of changes in body-size, in which case R would be of value in comparing follicle populations. Such changes could also arise, however, if the number of follicle groups increased but R remained the same ; in this case R could be misleading if used alone in comparing follicle populations.

(3) If $\left|\frac{\delta S}{S}\right| < \left|\frac{\delta P}{P}\right|$, both being of the same sign, R will *decrease* when $(P + S)$ is *increasing* (that is, δS positive) but *increase* when $(P + S)$ is *decreasing* (that is, δS negative).

Thus if follicle counts are used in comparing sheep, both P and R are necessary to obtain an estimate of the follicle population, together with body-weight, to enable an adjustment to be made for variation in surface area.

I thank various units of the Division of Animal Health and Production, Commonwealth Scientific and Industrial Research Organization, for their assistance. Counts were made at the Sheep Biology Laboratory, Prospect, while the sheep were maintained and sampled by the staff of the National Field Station.

Helen Newton Turner

Division of Animal Health and Production,
Commonwealth Scientific and
Industrial Research Organization,
McMaster Laboratory,
Parramatta Road,
Glebe, New South Wales.
April 9.

[1] Carter, H. B., *Anim. Breed. Abstr.*, **23**, 101 (1955).
[2] Turner, Helen Newton, Hayman, R. H., Riches, J. H., Roberts, N. F., and Wilson, L. T., Comm. Sci. and Indust. Res. Org. Div. Animal Health and Prod., Div. Rep. No. 4, Series SW-1 (1953).
[3] Carter, H. B., and Dowling, D. F., *Aust. J. Agric. Res.*, **5**, 745 (1954).

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned :

ASSISTANT CHEMIST (Fuel Technologist) (preferably with a degree in fuel technology or equivalent qualification, and previous industrial experience) in the Divisional Chemical Laboratory, Skelton Grange Power Station, Leeds, to be responsible for directing the work of the Fuel Section of the laboratory and to investigate general problems of fuel technology—The Divisional Secretary (Establishments), Central Electricity House, St. Mary's Road, Leeds 7 (August 18).

ASSISTANT LECTURER (with a good honours degree in physics or physical chemistry, and prepared to undertake research work on fibres) IN PAPER TECHNOLOGY in the Department of Textile Chemistry—The Registrar, College of Technology, Manchester 1 (August 20).

DRAUGHTSMAN IN THE DEPARTMENT OF ARCHÆOLOGY, to prepare for publication, scale drawings of objects, plans, diagrams, etc.—The Secretary, National Museum of Wales, Cardiff (August 20).

RESEARCH ASSISTANT (with at least an ordinary degree in physics or equivalent qualification) IN ROCK MAGNETISM in the Geophysics Section of the Department of Geology, for work on problems in palæomagnetism—The Registrar, The University, Birmingham (August 20).

ASSISTANT PHYSICIST, Basic grade (with a good honours degree in physics, and preferably experience in electronics and nuclear physics techniques) in the Physics Department of the Sheffield National Centre for Radiotherapy—The Secretary, "Broom Cross", Tree Root Walk, Sheffield 10 (August 24).

CARTOGRAPHER IN THE DEPARTMENT OF GEOGRAPHY—The Head of the Department of Geography, The University, Hull (August 24).

COMPUTER IN THE DEPARTMENT OF ECONOMICS—The Registrar, University College, Singleton Park, Swansea (August 25).

LECTURER or ASSISTANT (with a good honours degree in botany or agricultural botany) IN AGRICULTURAL BOTANY—The Secretary of the University Court, The University, Glasgow (August 25).

SENIOR SCIENTIFIC OFFICER (with a university degree in science, preferably with honours, with physics as the major subject, together with considerable experience of applied research in the field of physics), to be responsible for the planning and execution of research and related work in physics—The Director, Institute for Industrial Research and Standards, Glasnevin House, Ballymun Road, Dublin, Ireland (August 25).

ASSISTANT IN ELECTRICAL ENGINEERING—The Secretary of the University Court, The University, Glasgow (August 31).

ASSISTANT (with a degree in horticulture or botany or equivalent experience) IN THE POMOLOGY SECTION, to help with field experiments and in the supervision of recorders—The Secretary, East Malling Research Station, near Maidstone, Kent (August 31).

LECTURER IN THE DEPARTMENT OF METALLURGY—The Registrar, The University, Liverpool (August 31).

SENIOR LECTURER IN THE DEPARTMENT OF VETERINARY HYGIENE AND PREVENTIVE MEDICINE—The Secretary, University of Edinburgh, Royal (Dick) School of Veterinary Studies, Edinburgh (August 31).

SENIOR LECTURER (with special qualifications in taxonomy, and preferably acquainted with African flora) IN BOTANY, at the University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, August 31).

ASSISTANT LECTURER or LECTURER IN CLINICAL PSYCHOLOGY—The Registrar, The University, Leeds 2 (September 1).

CHEMISTS (with a first- or second-class honours degree or equivalent qualifications) at the Ministry of Supply Tropical Testing Establishment, Port Harcourt, Nigeria, for work on general problems associated with the scientific study of the behaviour of a wide variety of materials (plastics, rubber, metals, fibres, etc.) in tropical environments—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting F.51/6A (September 1).

SENIOR AGRICULTURAL ECONOMIST (with a good degree in economics or agriculture with economics, together with experience in farm management and advisory work) in the Department of Agricultural Economics—The Registrar, King's College, Newcastle-upon-Tyne (September 7).

ASSISTANT LECTURER (preferably with special interests and qualifications in geomorphology and biogeography) IN THE DEPARTMENT OF GEOGRAPHY—The Registrar, The University, Liverpool (September 8).

LECTURER IN ANIMAL PRODUCTION, and a LECTURER IN CROP AND GRASSLAND PRODUCTION—The Registrar, Wye College, Ashford, Kent (September 15).

LECTURER IN THE DEPARTMENT OF PATHOLOGY—The Secretary, The University, Edinburgh (September 15).

ERNEST CANNING RESEARCH SCHOLAR (with a good honours degree in metallurgy, chemistry or physics, and industrial or research experience) for fundamental research in metal finishing—The Registrar, The University, Nottingham (September 29).

LECTURER (with a degree in industrial chemistry or chemical engineering, preferably with honours, or an equivalent degree, and industrial experience in the field of industrial chemistry and/or chemical engineering) IN INDUSTRIAL CHEMISTRY at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 30).

DIRECTOR OF RESEARCH—The Chairman of Council, The British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey, marking envelope "Director—Confidential" (October 1).

KEEPER OF THE DEPARTMENT OF ANTIQUITIES in the Ashmolean Museum—The Registrar, University Registry, Oxford (October 1).

LECTURER IN METEOROLOGY—The Secretary of Faculties, University Registry, Oxford (October 1).

SENIOR LECTURER IN PSYCHOLOGY at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 1).

DEPUTY DIRECTOR (with a second-class honours degree in agriculture or sciences pertaining to agriculture, plus a high standard of basic education) OF THE WEST AFRICAN INSTITUTE FOR OIL PALM RESEARCH, Nigeria, to deal with all the Institute's business under the general instructions of the Director; to co-ordinate and organize the work of the research divisions; and to assist in the drawing up and directing of the Institute's research programme—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD/197/199/011.

FIELD OFFICER (Agriculture) (aged 30–40, with sound tropical experience of experimental farm management and a knowledge of preparing and recording experiments) IN THE TANGANYIKA GOVERNMENT AGRICULTURAL DEPARTMENT—The Crown Agents, 4 Millbank, London, S.W.1, quoting M3A/43540/TA.

LABORATORY SUPERINTENDENT (with A.I.S.T. or equivalent, and laboratory experience, preferably in geology or inorganic chemistry) IN THE NIGERIAN FEDERAL GOVERNMENT GEOLOGICAL SURVEY DEPARTMENT—The Crown Agents, 4 Millbank, London, S.W.1, quoting M3/43508/NF.

LECTURER (with an honours degree of a British university, and preferably industrial or teaching experience) to teach primarily Organic Chemistry—The Principal, Stockport College for Further Education, Wellington Road South, Stockport.

SENIOR SCIENTIFIC/SCIENTIFIC OFFICER (with a first- or second-class honours degree in physical or inorganic chemistry, or equivalent qualifications) to undertake basic research involving the study of various physical and chemical properties of solids at very high temperature (Ref. 1220/34); and SCIENTIFIC OFFICERS (with a first- or second-class honours degree in physics, mathematics or engineering, or equivalent qualifications) to carry out research and development work in the field of applied mechanics (Ref. 1221/34)—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting appropriate Ref. No.

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REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

The Prospects for International Investment. By Prof. W. Arthur Lewis. (Fourteenth Montague Burton Lecture on International Relations.) Pp. 12. (Leeds: The University, 1956.) *6d.* [255

Department of Scientific and Industrial Research: National Physical Laboratory. Wage Accounting by Electronic Computer. (Report No. 1 of the Inter-Departmental Study Group on the Application of Computer Techniques to Clerical Work.) Pp. ii+57. (London: H.M. Stationery Office, 1956.) *2s. 6d.* net. [255

Aero Research Technical Notes. Bulletin No. 159 (March, 1956): Glued Laminated Timber Structures—Part 1. By E. Niskanen. Pp. 4. (Duxford: Aero Research Limited, 1956.) [255

Sheffield City Libraries. Research Bibliographies (New Series). No. 62: A Select Bibliography on the CO_2 Process. Pp. 4. (Sheffield: Central Library, 1956.) [255

Studies on Tropical Echinoderms and Primitive Light Perception. By Prof. Norman Millott. (An Inaugural Lecture delivered at Bedford College, University of London, November 22nd 1955.) Pp. 12. (London: Bedford College, University of London, 1955.) [285

Observations Made at the Royal Observatory, Greenwich, in the year 1944, in Astronomy, Magnetism and Meteorology, under the Direction of Sir Harold Spencer Jones. Pp. viii+280. (London: H.M. Stationery Office, 1955.) *70s.* net. [285

Transactions of the Royal Society of Edinburgh. Vol. 63, Part 1 (No. 4): The Atrioventricular Pathway for Conduction of the Impulse for Cardiac Contraction in the Dog. By Dr. Francis Davies, Dr. E. T. B. Francis, D. R. Wood and E. A. Johnson. Pp. 71–84+1 plate. *4s. 3d.* Vol. 63, Part 1 (No. 5): The Leadhills-Wanlockhead Lead and Zinc Deposits. Dr. A. K. Temple. Pp. 85–114+1 plate. *8s.* Vol. 63, Part 1 (No. 6): The Heart and Great Vessels in the Strepsirhini. By W. C. Osman Hill and Prof. D. V. Davies. Pp. 115–128+3 plates. *5s. 6d.* (Edinburgh and London: Oliver and Boyd, Ltd., 1956.) [295

London School of Hygiene and Tropical Medicine, Incorporating the Ross Institute. Ross Institute Industrial Advisory Committee. Bulletin No. 5 (Revised, March 1956): The Housefly and Its Control. Pp. 24. (London: London School of Hygiene and Tropical Medicine, 1956.) [295

The Research Techniques Unit of the London School of Economics and Political Science: A Report on the First Five Years. Pp. 8. (London: London School of Economics and Political Science, 1956.) [16

The Preservation of Specimens by Embedding in Cold Setting Resin. By J. Rowland. Pp. 12. (Bishop's Stortford: E. M. Cromwell and Co., Ltd., 1956.) *1s.* [16

Institution of Gas Engineers. Publication No. 484: Liquid Methane. By Dr. J. Burns and L. J. Clark. Pp. 22. (London: Institution of Gas Engineers, 1956.) [16

Scientific Proceedings of the Royal Dublin Society. Vol. 27 (N.S.), No. 4 (9th February 1956): Pike (*Esox lucius* L.) in Three Irish Lakes. By Ann Healy. Pp. 51–68. *5s.* Vol. 27 (N.S.), No. 5 (28th April 1956): High Boiling Substances Present in Fusel Oil. By W. E. Boles, N. J. O'Connor and F. T. Riley. Pp. 69–74. *1s.* (Dublin: Royal Dublin Society, 1956.) [16

British Electrical and Allied Industries Research Association. Technical Report L/T345: A Phenomenological Treatment of Ferroelectricity and Antiferroelectricity in $NaNbO_3$. By Dr. L. E. Cross. Pp. 9+3 figures. 7s. 6d. Technical Report Z/T101: Combination Spectra in Long-Period Variable Stars. By Dr. C. E. R. Bruce. Pp. 11. 7s. 6d. (Leatherhead: British Electrical and Allied Industries Research Association, 1955.) [16

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 961, Vol. 249 (31 May 1956): Finite Plane Deformation of Thin Elastic Sheets Reinforced with Inextensible Cords. By J. D. Adkins. Pp. 125–150. (London: Royal Society, 1956.) 8s. 6d. [16

Proceedings of the Royal Irish Academy. Vol. 58, Section A, No. 1: Lower Bounds for the Dirichlet Integral in Euclidean n-Space. By the Rev. James McMahon. Pp. 12. 2s. Vol. 57, Section B, No. 14: Post-Boreal Pollen-Diagrams from Irish Raised-Bogs. By G. F. Mitchell. Pp. 185–252+plate 10. 7s. 6d. Vol. 58, Section B, No. 1: The Millstone Grit and Lower Coal Measures of the Leinster Coalfield. By W. E. Nevill. Pp. 16+5 plates. 3s. 6d. Vol. 58, Section B, No. 2: Salmon Movements Around Ireland—6: From Portballintrae, Co. Antrim (1953 and 1954). By Arthur E. J. Went. Pp. 17–22. 6d. (Dublin: Hodges, Figgis and Co., Ltd., 1956.) [16

Petroleum Information Bureau. U.K. Petroleum Industry Statistics relating to Consumption and Refinery Production, 1954 and 1955. Pp. 9. (London: Petroleum Information Bureau, 1956.) [16

Bulletin of the British Museum (Natural History). Entomology. Vol. 4, No. 6: Centrocneninae, a New Sub-Family of the Reduviidae (Hemiptera-Heteroptera). By N. C. E. Miller. Pp. 217–283. (London: British Museum (Natural History), 1956.) 15s. [56

Kent Incorporated Society for Promoting Experiments in Horticulture. East Malling Research Station Annual Report, 1955. (Forty-third year, 1st October, 1954 to 30th September, 1955.) Pp. 162+9 plates. (A.39.) (East Malling: East Malling Research Station, 1956.) 12s. 6d. net.; 2 dollars. [56

Department of Scientific and Industrial Research. Report of the Chemistry Research Board with the Report of the Director of the Chemical Research Laboratory for the year 1955. Pp. iv+88+1 plate. (London: H.M. Stationery Office, 1956.) 4s. net. [56

Building Research Station Digest. No. 88 (May 1955): Sound Insulation of Dwellings—1. Pp. 4. (London: H.M. Stationery Office, 1956.) 3d. net. [56

Admiralty Bulletin No. 78: The Royal Naval Surveying Service. By Captain C. C. Lowry and Lt.-Cmdr. G. J. B. Simeon, R.N. Pp. 8. (London: Chief of Naval Information, Admiralty, 1956.) [56

National Institute of Industrial Psychology. Report 12: An Experiment With Supervisory Training. By John D. Handyside. Pp. iv+48. (London: National Institute of Industrial Psychology, 1956.) [56

The Elementary Particles of Nature. Prepared by Dr. D. K. Butt, Dr. E. G. Michaelis, Dr. G. L. Miller, and Dr. P. T. Trent. Pp. 19. (London: Science Information Service, 1956.) [56

Air Ministry: Meteorological Office. Geophysical Memoirs. No. 94: Meteorological Results of the *Balaena* Expedition, 1946–47. By H. H. Lamb. Pp. 68+5 plates. (M.O. 584b.) (London: H.M. Stationery Office, 1956.) 8s. 6d. net. [56

Oundle School Natural History Society. Annual Report, 1955. Pp. ii+62. (Oundle: Oundle School Natural History Society, 1956.) [56

Other Countries

United States Department of the Interior: Geological Survey Bulletin 975–D: Geology of South-central Oriente, Cuba. By G. Edward Lewis and John A. Straczek. Pp. v+171–336+plates 19–22. n.p. Bulletin 1009–L: Radioactive Deposits in New Mexico. By T. G. Lovering. Pp. v+315–390+plates 17–23. 70 cents. Water-Supply Paper 1255: Water Resources of Southeastern Florida, with special reference to the Geology and Ground Water of the Miami Area. By G. G. Parker, G. E. Ferguson, S. K. Love and others. Pp. xxv+965+24 plates. n.p. Water-Supply Paper 1311: Compilation of Records of Surface Waters of the United States through September 1950. Part 7: Lower Mississippi River Basin. Prepared under the direction of J. V. B. Wells. Pp. iv+606+plate 1. 2.50 dollars. (Washington, D.C.: Government Printing Office, 1955 and 1956.) [255

Bulletin of the Geological Institutions of the University of Uppsala. Vol. 36, Parts 2–3: On the Early Ordovician of Sweden—Stratigraphy and Fauna. By Tortsten E. Tjernvik. Pp. 107–284+11 plates. (Uppsala: Almqvist and Wiksells Boktryckeri AB., 1956.) 30 Sw. Cr. [255

Food and Agriculture Organization of the United Nations. FAO Nutritional Studies No. 14: Protein Malnutrition in Brazil. By Dr. J. Waterlow and Dr. A. Vergara. Pp. vi+40. (Rome: Food and Agriculture Organization of the United Nations; London: H.M. Stationery Office, 1956.) 2s. 6d; 0.50 dollars. [285

Consejo Superior de Investigaciones Cientificas. Publicaciones del Instituto de Quimica "Alonso Barba." Vol. 9, Ano 1955. Pp. iii+233. (Madrid: Instituto de Quimica "Alonso Barba," 1956.) [285

Chronicle of the World Health Organization. Vol. 10, No. 4: The Work of WHO, 1955—a Review of the Annual Report of the Director-General. Pp. 89–120. (Geneva: World Health Organization; London: H.M. Stationery Office, 1956.) 1s. 9d.; 0.30 dollars; 1 Swiss franc. [285

Muelleria: an Australian Journal of Botany. Vol. 1, No. 1 (August 1955). Pp. 64. (Melbourne: Botanic Gardens and National Herbarium, 1955.) [285

Fourth Annual Report, July 1954–June 1955, of the Dutch-Norwegian Joint Establishment for Nuclear Energy Research. Pp. iii+34 (Kjeller, near Lillestrøm: Jener, 1956.) [285

Institut Royal Météorologique de Belgique. Publications Série S, No. 3: Comparaison Regionale des Radiosondes, Bruxelles, 4–XI–54—19–XI–54. Tome 1: Données Relatives aux Niveaux Standards et aux Niveaux Significatifs des Sondages P.T.U. Texte et Tableaux présentés par Dr. L. M. Malet. Pp. 96. (Bruxelles: Institut Royal Météorologique de Belgique, 1955.) [285

Canada: Department of Agriculture. Forest Biology Division: Science Service. Annual Report of the Forest Insect and Disease Survey, 1955. Pp. 106. (Ottawa: Queen's Printer, 1956.) [295

Fisheries Research Board of Canada. Bulletin No. 103: Fis... Handling and Hold Construction in Canadian North Atlantic Trawler... By W. A. MacCallum. Pp. vii+61. (Ottawa: Fisheries Researc... Board of Canada, 1955.) [29...

United States Department of the Interior: Geological Survey... Water Supply Paper 1269: Water Levels and Artesian Pressures i... Observation Wells in the United States. Part 5: Northwestern State... Prepared under the direction of A. N. Sayre. Pp. vi+172. 65 cent... Water Supply Paper, 1270: Water Levels and Artesian Pressures i... Observation Wells in the United States. Part 6: Southwestern Stat... and Territory of Hawaii. Prepared under the direction of A. N... Sayre. Pp. vii+253. 1 dollar. (Washington, D.C.: Governmen... Printing Office, 1956.) [1...

Klimatische Daten Basels für das praktische Leben. Von Dr. Ma... Bider. (Mitteilungen der Astronomisch-Meteorologischen Anstalt de... Universität, Basel. Meteorologische Reihe No. 3. Sonderabdruck au... Heft 1/1956 von "Wirtschaft und Verwaltung." Herausgegeben von... Statischen Amt des Kantons Basel-Stadt.) Pp. 48. (Basel: Statis... lisches Amt des Kantons, 1956.) [1...

Annual Report of the Calcutta School of Tropical Medicine, and th... Carmichael Hospital for Tropical Diseases, 1954. Pp. ii+132. (Ca... cutta: Calcutta School of Tropical Medicine and Carmichael Hospit... for Tropical Diseases, 1956.) [1...

Indian Forest Bulletin No. 187 (New Series): Identification ... Indian Lyctidae and Dinoderus Species. By R. N. Mathur. Pp. 1... (Delhi: Manager of Publications, 1956.) As. 5; 6d. [1...

Bulletin of the American Museum of Natural History. Vol. 11... Article 1: American *Hyracotherium* (Perissodactyla, Equidae). B... Prof. David B. Kitts. Pp. 1–60+plates 1–7. (New York: America... Museum of Natural History, 1956.) 1 dollar. [1...

Comptes Rendus des Travaux du Laboratoire Carlsberg. Sér... Physiologique. Vol. 26, No. 1–25: Volume Jubilaire en l'Honne... du Professeur Øvind Winge pour son 70ième Anniversaire. Pp. 44... (Copenhague: En Commission Chez H. Hagerup, 1956.) 40 Kr. [1...

Fonds National de la Recherche Scientifique. Vingt-huitièm... Rapport Annuel, 1954–1955. Pp. 269. (Bruxelles: Fonds Nation... de la Recherche Scientifique, 1955.) [1...

Milli Kütüphane Bibliyografya Enstitüsü Müdürlüğü, Ankar... Türkiye Bibliyografyasi. 1955–4: Ekim-Kasim-Aralik. Pp. 12... 1956–1: Ocak-Subat-Mart. Pp. v+103. (Ankara: Milli Kütüphan... Bibliyografya Enstitüsü Müdürlüğü, 1955 and 1956.) [1...

Deutscher Wetterdienst. Deutsches Meteorologisches Jahrbuch... 1954. Pp. xxxiv+223. (Bad Kissingen: Deutscher Wetterdiens... 1956.) [1...

Chicago Natural History Museum. Fieldiana: Anthropolog... Vol. 45: Higgins Flat Pueblo, Western New Mexico. By Paul ... Martin, John B. Rinaldo, Elaine A. Bluhm and Hugh C. Cutler. P... 218. (Chicago: Chicago Natural History Museum, 1956.) 4.... dollars. [1...

Europe's Growing Needs of Energy: How Can They Be Met? ... Report prepared by a Group of Experts. Pp. 120. (Paris: Organiz... tion for European Economic Co-operation; London: H.M. Stationer... Office, 1956.) 400 French francs; 8s.; 1.25 dollars. [5...

United States Department of the Interior: Geological Survey... Water Supply Paper 1355: Geology and Ground-Water Resources... of the Lower Yellowstone River Valley, between Glendive and Sidney... Montana. By Alfred E. Torrey and Francis A. Kohout. With a sec... tion on the Chemical Quality of the Water by Herbert A. Swenson... Pp. iv+92+2 plates. (Washington, D.C.: Government Printin... Office, 1956.) 1 dollar. [5...

British Guiana. Report on the Geological Survey Departmen... for the year 1954. Pp. i+106. 1 dollar; 4s. 2d. Bulletin No. 29... The Geology of the Issineru-Enachu District, Mazaruni River, Britis... Guiana. (An explanation of Sheet No. E.3, Issineru-Enachu, 1955... Compiled by E. R. Pollard. Pp. 63+1 map. 1 dollar; 4s. 2d. (Georg... town: Geological Survey, 1956.) [...

Government Forest Experiment Station, Meguro, Tokyo. Fore... Soils of Japan, Report 6 (March 1956). Pp. i+130+7 plates+5 map... (Tokyo: Government Forest Experiment Station, 1956.) [...

Department of Mines and Technical Surveys, Ottawa. Annu... Report for the fiscal year 1954–55. Pp. 118. (Ottawa: Queen... Printer, 1955.) [...

Department of Agriculture, Ottawa. Report of the Director ... Science Service for the year ended March 31, 1955. Pp. 68. (Ottawa... Queen's Printer, 1956.) [...

Metropolitan Life Insurance Company. Statistical Bulletin, Vol. ... (April, 1956): Perinatal Mortality. Pp. 12. (New York: Metr... politan Life Insurance Company, 1956.) [...

The Microstructure of Starch Grains. By Edith A. Roberts. P... 48 (12 plates). (Salem, Mass.: Edith A. Roberts, 17 Dearborn Stree... 1956.)

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